THE FRIENDLY STARS

MARTHA EVANS MARTIN

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THE
FRIENDLY STARS

BY

MARTHA EVANS MARTIN

WITH AN INTRODUCTION BY

HAROLD JACOBY, PH.D.

RUTHERFURD PROFESSOR OF ASTRONOMY
AT COLUMBIA UNIVERSITY

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BOOKS BY

MARTHA EVANS MARTIN

THE FRIENDLY STARS. Illustrated. Post 8vo

THE WAYS OF THE PLANETS. Illustrated. Post 8vo

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D—E

TO
B. C. M.

When I heard the learned astronomer,
When the proofs, the figures, were ranged in columns before me,
When I was shown the charts and diagrams, to add, divide, and measure them,
When I sitting heard the astronomer where he lectured with much applause in the lecture-room,
How soon unaccountable I became tired and sick,
Till rising and gliding out I wandered off by myself,
In the mystical moist night-air, and from time to time,
Looked up in perfect silence at the stars.

WALT WHITMAN.

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INTRODUCTORY NOTE

THE stars are here marshalled before us in a new and engaging manner; not as austere unchanging beacons of the universe; not as mere material for vivifying the results of profound mathematical analysis; but rather as they must have seemed to the herdsmen of old, and as they should appear to all who love the open air—rising constellation after constellation, nature's kindly reminders of the seasons as they come and go.

This the author has accomplished without sacrifice of scientific accuracy; that the grace of attractive form has been attained the reader will himself perceive. The book will serve a useful purpose, and help to arouse a wholesome popular interest in the stars; it is a pleasure to commend it to the reader's favor.

HAROLD JACOBY,
Rutherfurd Professor of Astronomy.

Columbia University, February, 1907.

THE FRIENDLY STARS

THE FRIENDLY STARS

INTRODUCTION

THE chief aim of this book is to share with others the pleasure which the writer has had in what may be called a relation of personal friendship with the stars. In this relation one knows the more conspicuous ones by name and at a glance; and is able to greet them as pleasant acquaintances when they return year after year in the due seasons, or each evening as they pass over their prescribed paths serene and stately, or dancing and twinkling, according to their several habits.

One has a fine sense of companionship with the stars when he has secured this kind of acquaintance with them—when on looking out of the window at any hour of the night he can see a familiar face twinkling at him as

if in friendly recognition of the fact that he must know it is due at that hour and is expecting to see it; or when, on a cold midnight in late February, before the trees and birds have announced the spring-time, he sees a bright, bluish, scintillating point just pushing up over the eastern horizon and knows that Vega has come to grace the skies again and that spring will surely come with her.

Such a feeling for the stars is not induced by exciting wonder at the expanse and mystery of the heavens, nor by burdening and oppressing the mind with the vastness that seems beyond all compassing in thought, but by showing how the stars, like the flowers and the trees, are but parts of the visible beauty of nature which have their share in making "the perfect whole."

Plants and birds come in their turn

> "As the revolving seasons rise
> Above the tree-tops star by star,"

and the steady advance of the changing season gets a definiteness and an interest to one otherwise impossible when he has learned to associate the visible signs of the progress of the year as they appear in the skies as well as on the earth. He will then associate

the blooming of the blood-root and the first warble of the bluebirds with the eastern splendor of Arcturus and the blooming of the maples. When he watches in the daytime for the first blue violets he will look the same evening for the blue twinkling face of Vega. He will know that the juncos and Sirius leave us at about the same time in the spring; that when the golden-rod and the wild asters are blooming it is time to look for Fomalhaut and that Antares is about to go; and a creaking, frosty night will make him involuntarily turn his eyes up to mighty Orion striding across the southern skies.

Such things as these, that are so dear to the heart of the lover of nature, are not learned as one learns a lesson, or by the being told, but by coming into a personal relation, a relation very easily established by one who really desires it, with the flowers and trees and birds and stars, knowing them all in their seasons and their associations.

For such knowledge as this no technical information is necessary, though it may be followed by a desire for technical knowledge. The two are quite different things. But one can come to no real appreciation of anything in nature without some knowledge of

particular objects. The acquirement of it is just as important and just as easy with the stars as with the flowers. One may revel in the beauty of a whole field of grass and flowers, but his heart gives a leap when he sees among them the face of some flower that he knows and likes, and he cries, "There's a lily," or a gentian, or whatever it may be. Birds may flit around us as we sit in the woods, and we note them as black, yellow, pretty, or whatever, and we think we are getting all the pleasure we can from them; but interest quickens when one comes that we can name, and it at once has an individuality and an importance which none the rest have.

So it is with the stars: a starry night is beautiful and we gaze at it and enjoy it and do not care to know more about it in detail. But if by chance we come to know by name one bright star, it immediately separates itself from all the others and becomes an individual. If we enlarge our acquaintance in the skies, the whole aspect of the heavens is changed, and, instead of a brilliant assembly of impersonal points of light, we see a host of individuals that we know as bright Capella, sombre Betelgeuse, and others.

And this satisfaction we may secure without troubling about meridians and ecliptics, or right ascension and declination, or any other of the scientific trappings of the stars, just as we have it with the flowers without attending to sepals and petals, or pistils and anthers, and with the birds without any thought of anatomical classification. The only thing one needs to do in order to have such an acquaintance with the stars is to look for them: and this book aims to show how and when and where to look for them in the easiest possible way.

Any especially scientific information will be omitted, the desire being to make the stars as interesting in themselves as possible and to show how simple a matter it is to know in an intelligent but untechnical way the choicest individuals among them, the leading facts concerning them, their bearing in practical life, and all that is individually beautiful and important about them. This, it is believed, will yield a pleasure such that any one who has once experienced it will feel is a very large reward for the small labor that it really entails.

Instead of its being a dry and difficult thing to acquire any particular knowledge of the

stars, one, if rightly directed, will find on pursuing the subject only just a little way that, while giving himself next to no trouble about it, he can soon come to know the more notable ones by name and to have a fair fund of practical information about them; and that many of the stars, which now all look so much alike to him, will have acquired such an individuality that he can recognize them at a glance in whatever position in the skies he may see them. And he will find, too, that the pleasure one never fails to have in the spectacle of the whole sky is multiplied many times for him as soon as he knows something of the individuals that make up this splendid panorama.

It is an interesting fact that the stars as individuals figure a great deal more prominently in old than in modern literature, and the writers of the older literature show a more personal acquaintance with them than the writers of the later literature show. This intimate knowledge of the stars really preceded the science of astronomy. The stars were better known even to people at large before there was any such science than they are known now, and there is only too much justice in Emerson's reproach that now, in

these days of nautical almanacs, "the man in the street does not know a star in the sky. The solstice he does not observe, the equinox he knows as little; and the whole bright calendar of the year is without a dial in his mind."

The explanation of this difference is that people in earlier times, being more out of doors than the people of the present day, were more observant of out-door objects and took more interest in them. For it is, after all, mainly a matter of observation; and for learning to know the leading stars and getting the interest that attends an acquaintance with them, little more is needful than simply looking at them. It is looking at them, too, with only the naked eye; for all the stars that attract special notice and have individual names were noticed and so named long before the invention of the telescope; and the principal constellations were traced and named by simple shepherds who tended their flocks at night in the open fields and had nothing to aid them but their own eyes and fancy.

I

THE RISING AND THE SETTING OF THE STARS

THE most favorable time for identifying a star is when it is rising, or has just risen, especially if its rising takes place anywhere between twilight and midnight, the portion of the day most likely to be convenient for observers. It is then in the eastern part of the sky, where the afterglow of the sunset does not dim its lustre, and it is far enough down towards the horizon for one to look at it face to face in a comfortable attitude. Moreover, at rising a star is more nearly by itself, more separated from neighboring stars, and is, therefore, much more easily recognized than when one has to pick it out from among the host of other stars already scattered over the sky and in as plain view as it. For near the horizon the atmosphere obliterates the multitude of

small stars which are plainly visible higher up in the sky.

It is true that, owing to the density of the atmosphere there, all stars twinkle more, and hence shine with less steadiness, when they are near the horizon than when they are higher up in the sky, and most stars are not to be seen at all until they have actually gotten some distance above the horizon. Then there is to be allowed for, the interference of buildings, trees, and other objects in the landscape; but, even in spite of these interferences, most any star comes well into view before it has risen so high that it cannot be easily separated from the others and looked at with comfort. One has the advantage given by the comparative isolation of a rising star whether it rises from below the horizon or from behind the trees and houses.

If one were observing a star through a telescope and for other purposes than that of identification, he should choose, as nearly as possible, a time when the star is in the middle of its course from east to west, or as nearly overhead as it ever reaches. There the atmosphere will be clearer and, in consequence, the star will shine with a steadier

light and offer less opportunity for optical illusions. But this means either a neck-breaking attitude or some special preparations for a comfortable reclining posture, either of which is more or less discouraging to one who has not already become pretty familiar with the stars. When he has come to know them, there is no greater delight than to lie stretched on a cot in the open with the whole expanse of the heavens above him, and watch them as they rise and pass and go again. This is the stage of acquaintance that binds one forever in friendship with the stars. But a speaking acquaintance may be maintained that will give much pleasure with lighter demands upon one.

The rising of the stars is the time of recognition and greeting. But it is no less important to speed the parting guest; and the next most satisfactory time to watch a star is when it has reached the western sky and is about to leave us until it comes again to the eastern door on its never-ceasing round. Here, while the star remains the same in its individual attributes, all its setting is the reverse of what it was when the star first appeared above the eastern horizon. The parallelogram of twinkling stars that

trailed behind Vega as she rose in the east now waves above her as she sinks below the line of vision in the west. The Northern Cross, which heaved itself into sight in the east almost wrong-side up, with Deneb weighting the head of it, has, twenty hours later, practically righted itself and is lost to view in the glowing west with Deneb dancing on the tip of its upright. So complete identification must include the recognition of a star both in the east and in the west.

In the north there is a circle of stars around the pole which are always visible to us. They complete their small round once in twenty-four hours; but their path lies entirely above the horizon, so they never rise or set. Within this circle are the Pole Star and the stars of the Great Dipper, which will be illustrated in the next chapter; but it includes none of the brightest stars.

Next comes a line of stars describing a larger circle around the pole, one that takes them below the horizon for a longer or shorter time according to their distance from the pivotal point, the pole. These stars rise in the northeast, make a long, slow sweep of the sky, and set in the northwest, finish-

ing their circle below the horizon and rising not long after they set. Among these are some of the brightest stars.

Then follows a belt of stars that rise somewhere near the exact eastern point of the horizon, cross the heavens to the western point in about twelve hours, and remain below the horizon another twelve hours.

And, finally, there are the stars in the southern section of the sky, which rise south of east and set in the southwest, never rising very high in the heavens, the portion of their circle, or course, over which we can see them pass being smaller and smaller as that course lies farther and farther south of us. Among these southern stars are Sirius, the star that outshines all the others, and Fomalhaut, that hides from us for sixteen hours out of each twenty-four.

All the stars that rise south of the exact eastern point on the horizon are called southern stars; for the sky is divided into a northern and a southern hemisphere by an equator running half-way between the north and the south pole, just as the earth is divided. The northernmost stars of the southern hemisphere are visible to us just as the southernmost stars of the northern

hemisphere are visible to people living in southern latitudes. These distinctions are of no great importance, but it is well to understand that, while we cannot see the southern stars as a body, yet some of them are visible to us and still are spoken of as southern stars. Three of the brightest stars that come within our view, Rigel, Antares, and Spica, are southern stars, in addition to Sirius and Fomalhaut, which have already been mentioned.

Unlike the sun and moon and the planets, each star rises always at practically the same point in the heavens. It comes back to the starting-point each day four minutes earlier than the day before, which makes it rise about an hour earlier each fortnight, and two hours earlier each month; so that in twelve months it comes twenty-four hours earlier. This brings it back to the same rising point at almost the same second once a year.

These changes from day to day in the time of the rising and the setting of the stars are regular and definite; and so it is an easy matter, after one has once learned to recognize a star, either by its appearance or its surroundings, to know where to look for it

at any given date. If a star, for instance, is due to rise at six o'clock in the evening on the first of March, it will rise at four in the afternoon in April, and at eight in the evening in February; at two o'clock in the afternoon in May, and at ten in the evening in January; at noon in June, and at midnight in December; and so on throughout the year. Hence, almost any star can be seen at some time in the night for six months in the year. The other six months, if it is among the northernmost stars, it can be seen more or less each night; but if it is among those that are below the horizon many hours, it may be above it during the hours of sunshine and thus be rendered invisible to the naked eye, though even in the daytime one can usually find a bright star with a telescope.

The times of rising and setting given in this book are for about the latitude of New York City, which is nearly forty-one degrees north latitude. For any place within five degrees of this latitude on either side the difference in time of rising is so slight that for mere purposes of identification it will not matter. The time of the appearance of the stars to persons within this belt of

latitude is the same all the way across the country from Maine to California. It includes the region around all the large cities of the Eastern and Middle States and most of the Western ones. Within it lie Portland, Boston, Philadelphia, Washington, Baltimore, Cincinnati, Indianapolis, Chicago, St. Paul, Detroit, Louisville, St. Louis, Denver, and San Francisco. On the southernmost edge of it is Memphis, and just a little outside of it on the north is Olympia, Washington. Above or below this belt one must take latitude more or less into consideration; which means only to remember that when an observer is placed farther south the stars to the north of him rise somewhat later and those to the south of him somewhat earlier, and that if he is placed north of this belt the stars to the south of him rise somewhat later and those to the north of him somewhat earlier. The rising-times of the stars as given here will answer approximately for any place in the United States.

When the rising-time of a star is referred to in these pages, it is usually given as nearly as possible in round numbers to avoid any complications. If the actual time, for instance, is 6:55, it is given as 7:00. Varia-

tions of this kind seldom extend over more than a few minutes and they more often give a time a little later instead of earlier than the exact minute. This makes the inexactness still more immaterial, since for naked eye observation one cannot hold the stars to their scheduled minute of rising, and anywhere within half an hour is a reasonable expectation in that regard. They are there, to be sure, but variations of climate between two places and variations of atmosphere from day to day will make a considerable difference in their visibility when near the horizon. After they are well up in the sky, of course, one need not make so many concessions.

It is to be remembered also that one is rarely ever situated where he can really see the horizon, but owing to various causes sees usually a line somewhat above the true horizon.

II

CONCERNING THE BRIGHTEST STARS

AMONG the hundreds of thousands of stars in the universe there are twenty which are so much brighter than the others as to make a class by themselves, and are known as stars of the first magnitude, or highest degree of brightness. These twenty stars are so scattered over the sky and so dominate each the section in which it is found, that if one comes to know them, there is no quarter of the heavens towards which he can turn his eye and not have a pleasant sense of familiarity with it.

Each one of these stars has a fixed place in the sky, and all, save three, have proper names of their own. The stars in general are not known by individual names; so it is a matter of congratulation that nearly all the bright ones are so known, and especially

that this is true of all the brightest stars that can be seen in our latitude. The fixed place they have in common with all the other stars, which, when once their place is known, can always be found in the same spot. For the stars are steadfast. Spring, summer, autumn and winter each has its own bright stellar setting, and we can always count on its appearing with unchanging beauty and unfailing promptness. The moon comes and goes. She is the symbol of inconstancy. The planets wander from place to place—most of them easy enough to find, but continually changing in brightness and position. Only the stars are always the same.

The names of the twenty brightest stars, given in the order of their brightness, are as follows:

Sirius	pronounced	Sir′-i-us
Canopus	"	Ka-nō′-pus
Alpha Centauri	"	Al-fa Sen-tâ′-rē
Vega	"	Vē′-ga
Capella	"	Ka-pel′-a
Arcturus	"	Ärk-tū′-rus
Rigel	"	Rē′-jel, or Ri′-jel
Procyon	"	Prō′-si-on
Achernar	"	A-ker′-när
Beta Centauri	"	Bā-ta Sen-tâ′-rē
Altair	"	Al-tāre′

Betelgeuse	pronounced	Bet-el-gerz′
Alpha Crucis ...	"	Al-fa crū-′sis
Aldebaran	"	Al-deb′-a-ran
Spica	"	Spī′-ka
Pollux	"	Pol′-uks
Antares	"	An-tā′-rēz
Fomalhaut	"	Fō′-mal-o
Deneb, or Arided	"	Den′-eb, or A′-ri-ded
Regulus	"	Reg′-u-lus

There are five stars among the twenty brightest which are so far south that they cannot be seen in our latitude. But they are important and beautiful, and it may be worth while to speak of them briefly before we pass on to the others of this bright company with whom we hope to have a friendly acquaintance. These five stars are Canopus, Alpha Centauri, Beta Centauri, Alpha Crucis, and Achernar. In some parts of Florida and Texas, Achernar can be seen low in the south for a short time in the evening, and Canopus, which is a little farther north, can be seen a somewhat longer time and higher up in the sky. All five of these stars can be seen in Cuba. It is to be regretted that they must remain hidden from us, for there are special reasons why some of them would interest us, aside from their great beauty.

Canopus, for instance, is far brighter than

any star visible in the northern hemisphere save one, the brilliant star Sirius, and Canopus is so much farther away than Sirius that it must be many times larger and really give many times more heat and light. It is, in fact, one of the largest bodies in the universe; for with all its superior brilliancy, it is still so far away that we have no certain estimate of its distance. Sirius, though it outshines Canopus to our view, is comparatively near us, and its greater brightness may be on that account.

Incidentally, it may be interesting to know that Canopus is credited with having run away with one of the Pleiades. If he did the deed, he has succeeded in concealing the proof of it, for the lost Pleiad has never been seen elsewhere since she was reputed to have disappeared from her place among her six sisters.

Alpha Centauri is distinguished as being, so far as is now known, the one star of all, of whatever degree of brightness, that is nearest to us. It is not near enough for any inconvenient neighborliness, as we shall find later on; but a stretch of a few hundred millions of miles in shortening the distance to our nearest neighbor is worth taking into

account and setting down to the credit of Alpha Centauri.

This star is called by certain French astronomers Proxima, on account of its nearness to us; but the name has not come into any general use, nor does it seem very desirable that it should. For all our feeling that so important a star ought to have an individual name, Proxima does not seem the right choice. It may well be that in the course of time other stars will be found to be nearer to us than Alpha Centauri, and the name would then have no appropriateness.

Beta Centauri is a brilliant star, not quite so bright as Alpha. The two stars lie very near together. The distance between them is about four degrees. This is a little more than the distance between Castor and Pollux and not quite so much as that between the two pointers in the Dipper. Alpha Crucis, almost as bright, lies not far away, and the three stars make a brilliant spectacle in the southern sky. Achernar, but little below Alpha Centauri in brightness, is the only very bright star in its section of the southern heavens.

The other fifteen of the brightest stars are all visible to us, and are the ones we shall seek

to know first. After they are well identified it will be easy to point out others, less brilliant, but perhaps not less significant.

To find any of these stars only two things are necessary to be known as a basis from which to work: the constellation known as the Big Dipper, and the North Star (Polaris is its name).

The Big Dipper is a large constellation (part of a still larger one called the Great

THE BIG DIPPER

Bear) consisting of seven principal stars, all very bright, but none of them among the twenty brightest, grouped so as to resemble the outline of a dipper.

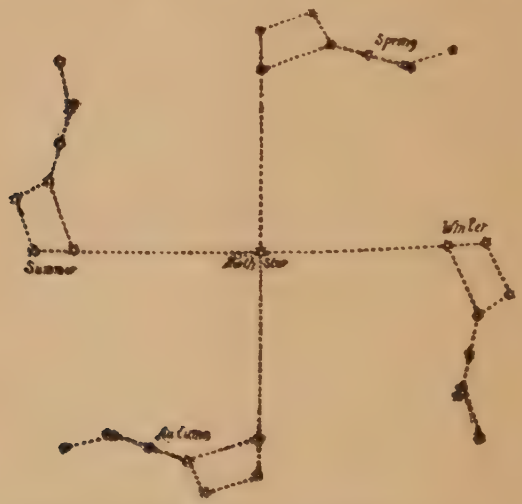
This constellation is so conspicuous and, hence, so easy to find, that it is known to most persons. It is one of the few constellations that really look like the things after which they are named. It lies in the

northern heavens, and in our latitude is above the horizon all night, so that it can always be seen when the skies are clear. The two stars on the outer side of the bowl are called the "pointers," because a line drawn through them from bottom to top will point towards the North Star, and, if extended to about five times the distance between the two stars, will end, not exactly, but yet so nearly at Polaris that there will be no mistaking the star.

The North Star marks the centre, or pole, around which the celestial sphere revolves, and the pointers always hold the same relative situation to it no matter how the dipper is turned with relation to us. The North Star and the Dipper as they appear to an observer on the earth in our latitude at the different seasons of the year have the relative position shown in the illustration.

Inasmuch as all the stars seen in the northern hemisphere of the heavens revolve around the point marked by the North Star, their positions relative to one another are always the same. So if one bears this in mind, it will be just as easy to find them at one time in the year, or in the evening, as at another. The positions given in the dia-

gram of the Dipper are as the stars composing it appear early in the evening at the seasons named. They make a circuit of the pole each twenty-four hours, so that if one



RELATIVE POSITION OF THE NORTH STAR AND THE DIPPER

watches all night he can see them in at least three of these positions each night in winter and in two of them during the short nights of summer. Into the other positions they come, of course, in the daytime.

The distance between the two pointers is about five degrees; and this is an important thing to keep in mind. These known five degrees may be used as a unit of measure in finding other stars as described in this book. If one cannot carry the distance between the pointers in his mind from one part of the skies to another and thus make comparisons of distances that will be approximately correct, he can take a stiff piece of card-board, or an adjustable ruler, and, holding it out at arm's-length, adjust it so as to exactly cover the space between the two pointers. He will then have a fairly accurate measure of five degrees in the sky and will probably be surprised to find that it will require a little less than three inches on his ruler to cover it. This will be of great assistance in marking off approximate distances on the surface of the heavens as it appears to us, and will enable one to follow the directions given in these pages. It will be a still further convenience to make a measure from two to four times as long, thus covering ten or twenty degrees. In adjusting these measures it will be found necessary to sight with one eye only, keeping the other closed. One cannot cover a star

from both eyes with a ruler at only an arm's-length away.

While these rough guides are conveniences to one entirely unaccustomed to observing the skies, a very little experience will soon enable one to estimate distances from star to star by the eye alone with sufficient accuracy to identify any conspicuous object in the heavens.

In looking for the brightest stars one may sometimes find himself confused by four bright stars which are not, after all, true stars, but are the planets Venus, Jupiter, Saturn, and Mars. Stars are suns and shine by their own light, as our sun does. Planets are dark bodies and shine only by light reflected from the sun. If the planets were as far away as the stars, they would be entirely invisible, and all the differences between them and the stars which I am about to enumerate are due entirely to their comparative nearness to us.

There are seven planets besides the earth, but the four already mentioned are the only ones likely to be mistaken for true stars and thus prove confusing to the ordinary observer. Of the other three, two (Neptune and Uranus) can be seen only with a tele-

scope, and the other (Mercury) on account of its nearness to the sun is rarely seen at all by the ordinary observer, though when it is visible it appears as a rather bright star.

The first two, Venus and Jupiter, are at certain times brighter than the brightest stars. Venus sometimes shines so that it casts a shadow and sometimes can be seen, like the moon, in daylight. Saturn is usually as bright as a first magnitude star, and Mars varies so that it sometimes equals Saturn in brilliancy and sometimes is not so bright. They all move about in the heavens with seeming irregularity, and when they are in the region of any bright star may easily be mistaken for it by an untrained observer. A little careful observation, however, will show that they are not as the other stars. They are not fixed in their places, and a few nights of watching will make this apparent. They do not twinkle as the stars do, but shine with a steadier light. They are not mere points of light, as the stars are, but show as actual bodies and sometimes at their brightest even as rotund solid bodies, though small in comparison with the other two bodies of which we can see the outlines: the sun and the moon. A very little watching

will make one familiar with their appearance so that he can always tell Venus and Jupiter at a glance and usually Saturn and Mars.

Their positions in the heavens are hard to describe definitely because the planets are constantly changing. They do, however, keep within a certain limited path, which is within a few degrees of the path that the moon follows as it threads its way among the stars each month, and at some time during the month it passes near each planet. This is sufficient to indicate that the planets are never found very far south or very far north.

Venus has still the further limitation of never being more than about forty-five degrees away from the sun. When it is in the evening sky it sets never much more than three hours after the sun, and when it is seen in the morning it rises never more than about three hours earlier than the sun. The other planets within their limited path already described rise and set at various times within twelve hours of the rising and setting of the sun.

The planets have each a distinctive color, which will assist somewhat in identifying them. Jupiter is white; Venus is a little

tinged with yellow, Saturn is decidedly yellow, and Mars is fiery red.

There are many interesting things to observe about the planets, which are a study in themselves. This brief outline of their appearance and locations in the sky will be sufficient to prevent one from confusing them with the stars, which are the special objects of our quest at present; and with the North Star and the Dipper well in mind, we are now ready to be introduced to the brightest of them.

III

CAPELLA

CAPELLA is a charming star that has the distinction of being situated nearer to the North Star than any other of the brightest stars. It can be found by drawing a line forty-five degrees long from Polaris at a right angle to the line from the pointers to the pole and running in an opposite direction from the handle of the Dipper. It is also pointed out by a line starting at the star which marks the bottom of the Dipper on the handle side and running thence about half-way between the two pointers, for a distance of about fifty degrees, or to the first bright star, which is Capella. If these directions are even approximately followed Capella can be discovered, for there is no other star in its neighborhood that in any way compares with it in brightness.

Capella is one of the most brilliant stars

in the heavens. Not many years ago it was classed by the best authorities as the brightest in the northern hemisphere of the skies. Sirius, as we know, always shines with greater brilliancy than any other star; but Sirius lies south of the equator and does not belong among the stars of the northern hemisphere, although in our latitude it, fortunately, can be seen.

In recent years, however, possibly on account of a real change in brilliancy, but probably by reason of more delicate measurements of its light, Capella has been found to be very slightly less lustrous than one other bright star that is classed as northern. The difference is so trifling that it might well be questioned by an ordinary observer, and is really not of much importance since the two stars are so nearly equal in brilliancy and each in its way has its own peculiar charm.

Being so far north, Capella is above the horizon more than twenty hours out of each twenty-four, so that it can be seen at some time in the night every month in the year, and one comes to be on most familiar and friendly terms with its bright face. Its first appearance in the skies of the early evening is in August, when it rises about ten

o'clock during the first half of the month; and it remains a constant ornament of the nights until the latter part of the following June. July is the only month in which it does not show its face at some time before midnight; and even in July, if one watches closely late in the month, he can have glimpses of the star following the evening sun at no great distance and almost lost in the sunset glow. In October it rises just as the sun is setting.

Capella rises almost exactly in the northeast and swings in a fine long circle over the heavens during its twenty-hour journey to the northwest, where it sets for a brief time, and then rises again in about four hours.

When you watch the birds congregating in noisy flocks in the morning for the fall migration, and in the afternoon gather the first fringed gentians, look for Capella in the northeastern sky in the evening. When the trees are bare and the berries are wrapped in ice and snow, so that the winter birds greedily gather what in your bounty you throw to them, you will find Capella shining almost directly overhead early in the evening. During the spring months, when the air is full of the stir of the awakening earth, and other

stars are demanding our attention to their return in the east after long absences, Capella is hurrying on towards the northwest, no longer charming us with its novelty, but still as bright and fair as ever and ready to fill its place in the brilliant gathering of the stars of spring.

Capella is yellow in color like our sun (which is a star). In its life as a star it is at about the same stage of existence as the sun and shows about the same chemical composition. Being of the same type as the sun, it gives something near an equal amount of heat and light in proportion to its size. But it is so much larger than our sun that it really gives out at least one hundred and twenty times more light. Its distance is so great that its light requires nearly forty years to reach us in its journey through space, though travelling, as light does, with a swiftness of about 186,000 miles a second. At the distance of the nearest fixed star, our beautiful big sun would shine as a star no brighter than Polaris. But Capella is nine times farther away than the nearest fixed star, and still shines as one of the brightest of the bright stars. If Capella were inhabited, our sun would appear to its people

as one of the faintest stars that we can see with ease. But it is not inhabited, for it is a very hot, rarefied and expanded body, as much as forty times rarer than our sun, and like the other bright stars, no place for the existence of life as we know it.

It has been discovered in recent years that Capella is not alone as it makes its journey through the black void. Like so many other stars, it is what is known as a binary system, or a double star, and has a companion which lies so near it that they circle around each other in a little more than a hundred days, or less than one-third of the time that it takes the earth to go around the sun.

Capella and its companion have never been seen separately even with the assistance of the strongest telescope. But the wizard spectroscope has penetrated their family secret and by its means astronomers have learned that they are two immense, fiery bodies of nearly the same size and perhaps a hundred times more voluminous than the sun, whirling with incredible speed about each other. The diameter of the orbit over which the two stars spin is so large that we could string more than a hundred suns along

it and still have room left for a few more shining beads of the same sort.

Since it has been known that Capella is a double star it has been seen through at least one telescope as oval instead of round, showing that the two stars have been caught at a place in their orbit where they appeared side by side to our view.

These are interesting facts that science has to tell us about Capella; but the star that fixes itself in our regard is the fair, golden, bright Capella that decks the sky in its season. We follow it in its course visible to us across the heavens, we joy in its beauty and feel the kindly influence that astrologers have always ascribed to it, and find its gentle light no less gentle on account of its being the composite of the great orbs we know it is.

Capella is at present receding from us at the rate of about twenty miles a second, or more than a million miles a day. At first thought this rather makes us fear that we are in danger of losing this beautiful star from view. But it will be many hundreds of years before even under such speeding away there will be any appreciable change in its brightness.

The constellation of which Capella forms

a part is called Auriga. It is a five-sided figure somewhat in the shape of a shield. It can be easily recognized as soon as Capella is located. It will be described among the constellations later on.

IV

ARCTURUS

EARLY in the evening in March another bright star may be seen rising a little north of east, which is among the choicest of the heavenly bodies. This is Arcturus. To find it begin at the end of the handle of the Big Dipper and, following the curve of the handle, extend a line about thirty degrees, or until you come to the first brilliantly shining star. There is no other very bright star in this region; so the line cannot point you to any other than Arcturus, the self-same star whose bright beams flowed down more than twenty-six hundred years ago upon the patient Job and is named by him along with other wonders of the divine creation.

When one has learned to know the ways of Arcturus and cares to greet him as he first comes to take his place among the evening stars in the spring, one begins about ten

o'clock in the evening in February to watch the handle of the Dipper, so clearly, to the expectant observer, pointing to something important just below the horizon and then slowly rising until it has pulled into view the steady shining face of Arcturus. A less attentive observer is more likely to notice the star in March and April, when the Dipper is almost directly overhead and is turned as neatly upside down as if it were on the pantry shelf. Its handle, though, still points to Arcturus, now climbing the eastern skies composedly but rapidly, and making way for the other bright stars of the spring that will bring on the scene a stellar setting of their own.

Arcturus rises on the first of March about eight o'clock in the evening, and during this month, when the horse-chestnut buds are swelling and the elm-trees are putting forth their first brown blossoms, and the hawks and owls and crows are prospecting for nesting sites among the high trees, Arcturus, as if impelled by the onrush of spring, is returning four minutes earlier each evening until at the beginning of April the star rises just as the sun sets.

This is really the month of its greatest

glory. It shines all through the evening in the eastern heavens, bright even when the moon is full, and, fitting in with all the other aspects of nature, gives a splendid close to the splendid days of late April. What more gracious day's progress in beauty could there be than to travel with the eye from the cheerful hepaticas dotting the soft ground among the trees to the round, white, silent blossoms of the dogwood fringing the late April woods and thence, when evening falls, to the bright yet gentle light of Arcturus in the sky, announcing the end of the purple twilight.

By the middle of June, Arcturus may be found during the early evening almost overhead, and it remains in this region during July. After this, one sees plainly that it is travelling towards the northwest, sinking lower and lower each month until, near the last of November, the pointing handle of the Dipper (the Dipper being then right-side up and below the pole) shows us that it has gone, almost at the same moment with the sun, below the northwestern horizon. It is in the evening skies no more until the next spring. If one wants to see Arcturus in December or January, he must look for it

in the east between midnight and dawn. It shines for us at some time between sunset and midnight almost ten months in the year. It requires about fourteen and a half hours to complete its journey from rising to setting each day.

Arcturus and Capella are so nearly equal in brightness that astronomers differ as to which outranks the other, even when they measure their light with a supposedly accurate instrument and a trained eye. To my own eye Arcturus outshines Capella, and on asking various inexperienced persons for off-hand opinions as to the relative brightness of the two stars, I have invariably had an answer in favor of Arcturus. The best authorities, however, make Capella a shade brighter.

Arcturus, like Capella, is yellow in color and is known as a solar, or sun, type of star. It is, however, as one can plainly see, a little more tinged with red; and this indicates that it is perhaps a little farther along in its development from a gaseous to a solid body than either Capella or the sun, and that it is probably not quite so bright in proportion to its size.

Situated as we are, the sun gives to the

earth billions of times as much light as Arcturus; but if the sun were as far away as Arcturus is, it would be one of the telescopic stars, entirely invisible to the naked eye. In actual light-giving power Arcturus exceeds the sun a thousand times. Its extreme distance is all that saves us from this tremendous light. It is so far away that with the unthinkable speed of light more than a hundred years must be required for it to come from Arcturus to us. If the star were blotted out of existence, the light that left it on the day of the catastrophe would, a hundred years later, still be travelling towards us and we should probably still be in ignorance of the fate of the star. Astronomers are fond of saying, and it is strictly true, that we see the stars only as they have been and never as they are.

Arcturus ranks with Canopus as one of the largest bodies in the universe. The diameter of our own sun is more than 866,000 miles, yet the sun is small in comparison with Arcturus, whose diameter is supposed to be several millions of miles. It is said also to be probably the hottest star in the universe; but this perhaps may prove to be a too precipitate statement. Actual results from

experimental measurements of the heat of stars are very few, though Arcturus has been shown to give out more heat than Vega, another star with which it has been directly compared.

These facts are, perhaps, not what we most want to have in mind when we gaze into the face of Arcturus with its clear, steady light, but they must have their part in the sum of its general characteristics and some influence in determining our feeling towards the star.

Arcturus has the distinction of having the most rapid motion of any of the brightest stars and it is among the swiftest moving of all the stars visible to the naked eye. Enormous body as it is, we know that it is bowling along through space at the rate of between two and three hundred miles a second. It has been doing this for untold centuries, and yet it does not change its position to our view a distance of more than one-eighth of the apparent diameter of the moon in a century. This is, however, an enormous change for a "fixed" star and will, in the course of ages, make an important difference in the position of Arcturus among the other stars.

It is pleasant to know that this bright star

is approaching us, though it lessens the distance between itself and us only at the rate of about five miles a second, a very loitering gait in comparison with the speed of stars in general. The most that it can mean to us is that Arcturus will not grow less bright in our skies, for at this rate of approach untold centuries must pass before the distance between us and the star is lessened so as to make any appreciable increase in its brightness. Such increase, indeed, possibly never will be made; for Arcturus is growing old, and it may be that its lustre will diminish as its distance decreases.

Arcturus lies in the constellation Boötes and is, of course, its brightest star.

V

SPICA

ANOTHER bright star, and one that comes into view not long after Arcturus, is Spica. It is not so bright as Arcturus, but is still a conspicuously brilliant star. Among the twenty brightest it is the fifteenth in order of brilliancy. It can be found by extending the line from the end of the handle of the Dipper through Arcturus and about thirty degrees beyond, still following the curve. It is about as far from Arcturus as Arcturus is from the handle of the Dipper. A straight line beginning at the pointer nearest the pole, running through the star at the bottom of the Dipper on the handle side, and extended about sixty-five degrees farther on, will also point out Spica.

Spica rises a very little south of the exact eastern point on the horizon and becomes visible about an hour later than Arcturus.

It is the only very bright star in the south-eastern part of the heavens during the early spring months, and one cannot easily fail to identify it even without the specific directions for finding it that are here given. It first attracts one's attention in the early evening about the middle of March, at which time it rises about eight o'clock and by nine has cleared its face of the haziness of the lower atmosphere and is shining with a clear white light.

Spica does not make so long a sweep across the heavens as Capella and Arcturus do. It is one of the stars that lie a little south of the celestial equator, and at the highest point in its journey across the sky it is still to the south of us and almost one-half of the way up from the horizon to the point exactly overhead, which we call the zenith. It takes five hours and a half to reach its highest point and as many more to travel to the southwestern horizon, where it sets eleven hours after it has risen.

Spica rises just after the sun sets in the early part of April; and during April and May it is at its best in the eastern evening sky. Its position, however, keeping it always comparatively low in the sky to our view,

makes it easy to observe at all times when it is visible. During the short evenings in June it is seen bearing off towards the southwest, where in August it sets about ten o'clock, in September at about eight o'clock, and in October about the same time that the sun goes down. It can be seen between sunset and midnight in some part of the sky from the middle of February to the early part of October. In November, December, and January it rises between midnight and dawn, so that October is the only month during which it is most of the time invisible. This is because it lies in the constellation Virgo, or the Virgin, through which the sun is passing in October, and the star is lost in the rays of the sun. Spica lies almost on the ecliptic, which is the line that marks the annual path of the sun through the heavens.

Spica's color (white) shows it to be in an earlier stage of existence than the yellow stars; hence it is known to be a much more tenuous, or rarefied, body than either Capella or Arcturus. It is one of the stars so far away that we have never been able to measure its distance. Shining so brightly as it does at an immeasurable distance, it must be of immense size and perhaps thousands of

times brighter than our sun. The spectroscope has revealed that it is probably a double star and that it is moving towards the earth at the rate of more than fourteen miles a second. Perhaps in ages to come it will be near enough to yield some clue to its distance.

The name Spica means an ear of wheat, and the star marks the spot in the constellation Virgo where the Virgin holds in her hand a spear of wheat.

VI

VEGA

ABOUT three hours after Arcturus has risen there will come peeping over the northeastern horizon a brilliant, bluish star which twinkles so gayly and commands such instant admiration that its entrance into view has almost a dramatic effect. This is Vega, the third of the trio of bright stars that give a May-dance around the pole. Her companions, bright Capella and steady-shining Arcturus, are already gliding smoothly over the shining surface of the sky when she, clearing the tree-tops almost with a bound, lightly springs into view and the vernal festival is on.

The point on the horizon at which Vega makes her appearance is about fifty degrees from the pole. She lacks about seven degrees of being as far north as Capella, and is nearly twenty degrees farther north than Arcturus.

To find Vega, draw a line from the star at the junction of the bowl and the handle of the Dipper to Polaris. Then draw a line at right-angles to this nearly forty degrees in length and on the same side of the Dipper from which the handle projects, and it will point out the brilliant, beautiful Vega. The star is the only conspicuous one in the region described, and no other star can be mistaken for it.

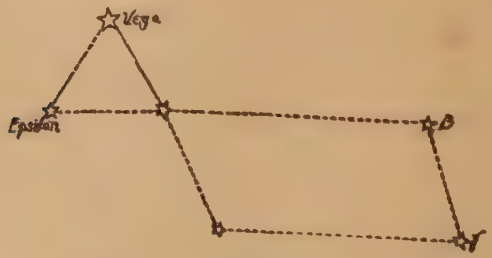
Vega is on the opposite side of the pole from Capella, but the two stars are usually seen in the sky at the same time. In the spring, when Vega decks the eastern heavens, Capella glows in the northwest. In the autumn, when Capella comes sparkling over the dark purple sky in the northeast, Vega may be seen flying with its attendant stars down towards the northwest. Each one is hidden below the horizon for the few hours that the other holds the centre of the celestial stage and is at its highest point in its nightly course across the jewelled dome of the sky.

Making Vega the starting-point of measurement, Arcturus is about one-third of the way between Vega and Capella, though a little farther away from the pole. His part in the gay spring festivities is very conspicuous,

and at that time the three stars are closely associated in their splendid, twinkling circuit around the pole which it may please our fancy to watch during the first soft nights of spring. In the autumn, when Vega and Capella have changed places in the evening skies, Arcturus is below the horizon and cannot be seen.

If one is in any doubt about the identity of Vega, it can always be recognized at a glance by the fact that there is following it four dainty stars arranged in an oblique parallelogram.

The position shown in the drawing is the one they always hold relative to Vega.



VEGA AS SHE APPEARS IN THE EAST

When we see her in the east as she brightens the evening view in the spring and early

summer the four stars are to the east of, or below, her; in the late autumn and winter, when the constellation is in the western sky, the position of the stars, as it appears to us, is partly reversed, and, with Vega leading them towards the northwestern horizon, they appear as shown in the illustration.

VEGA AND HER ATTENDANT STARS IN THE NORTHWEST

Vega, like Capella, can be seen in our latitude at some time during the night every night in the year. One can see it even between sunset and midnight every night in the year. But to do this it will be necessary to keep a sharp lookout low in the northwest very early in the evenings in February and to turn just as sharp eyes towards the northeast between eleven and twelve o'clock in the early part of March. As April progresses the star more and more asserts its

supremacy in the northeastern heavens. During the latter part of this month and all of May it is singularly beautiful as it passes almost airily between us and the rich dark background so full of color characteristic of the spring-time sky.

Vega is the chief star in the constellation called the Lyre—once fancied to be the magic lyre which in Orpheus's hands gave forth music that tamed wild beasts and chained the rivers in their courses. It is easy to get some sense of the fancy that gave the constellation its name as we watch it during the lovely spring evenings floating lightly in the sky, the parallel lines connecting its principal stars vaguely suggestive, to the willing mind, of some quaint stringed instrument that under a magic touch might send out heavenly music through the resonant air.

Early in May the star rises at about the same hour that the sun sets, and all summer long it is the gayest and perhaps the most instantly attractive star in the evening skies. It is the star so often noticed and commented on as shining with great brilliancy directly overhead between nine and ten o'clock during the hot summer evenings of July and August. When autumn comes it has passed

the highest point in its journey across the heavens and may be seen travelling towards the northwest. Here it shines splendidly during the early evening, setting in December somewhere near eleven o'clock and in January about nine. It is above the horizon eighteen hours out of each twenty-four and rises six hours after it has set.

Vega is the most brilliant star in the skies of the northern hemisphere, though its supremacy is closely contested by Capella and Arcturus. There are only three stars in the entire heavens, north or south, that are brighter. These are Sirius, Canopus, and Alpha Centauri, all stars of the southern hemisphere. Sirius, as we know, can be seen in our latitude, but it lies south of the celestial equator, and is, therefore, called a southern star. The other two lie so far south that they do not come within our view.

Vega is one of the very large suns of the universe and gives out about ninety times as much light as our sun. Its distance is such that it requires about twenty-nine years for light to travel from it to us, which shows it to be somewhat nearer to us than Capella and very much nearer than Arcturus.

It is coming nearer all the time, too. Thirty-four miles a second is about the rate at which it is approaching us; but, as we have already seen, it will take many centuries for even such almost incredible speed as that to make any appreciable difference to us in the brightness of a star.

Vega is the same type of star as Spica. It is in a much earlier stage of development, and, consequently, is a much less solid body than either Capella or Arcturus. It is also less hot than either of these two stars; for they are like our sun, and the solar type of star is now supposed to be at its hottest stage.

Vega has a companion star, much smaller than itself, revolving around it, which is of the same beautiful bluish color as the larger star. The companion is of about the tenth magnitude and can be seen only with a large telescope. Vega is about four thousand times brighter than her companion.

One of the most interesting things about Vega is that it seems to mark, or nearly mark, the point towards which our sun with all his planets is travelling.

VII

DENEB, OR ARIDED

A LITTLE more than an hour after Vega has risen, a very bright twinkling star will appear on the northeastern horizon at a point about forty-five degrees from the Pole Star. This is Deneb, next to the least bright of the twenty brightest stars, but a very interesting and beautiful star. It lies in one of the densest parts of the Milky Way and is conspicuously brilliant in contrast with the hazy light of the myriads of small stars that go to make up this mysterious belt of shining bodies.

Deneb is about six degrees farther north than Vega and only about one degree farther south than Capella, which, as we have seen, is the northernmost of all the bright stars. To the ordinary view Deneb and Capella seem to rise at about the same spot on the horizon, and they describe very much the

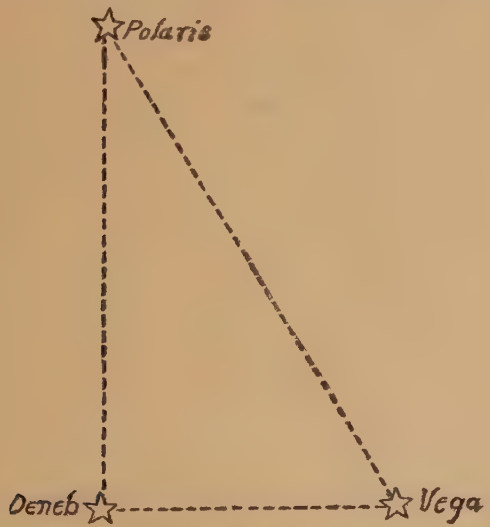
same long, oblique curve across the heavens as they pass from rising to setting. Capella being a little farther north, is above the horizon perhaps half an hour longer than Deneb; but they each take approximately ten hours to come to the highest point in their path across the sky, and, consequently, in a favorable atmosphere, can be seen for about twenty hours each day, except when they are obscured by the sunlight. The highest point a star ever reaches in its daily course over the heavens is marked by what astronomers call its meridian, and when it is at this point it is said to be "on the meridian."

A line drawn from Polaris to Deneb and thence on to Vega forms a right-angled triangle of which Deneb lies in the right-angle.

Deneb forms a part of a figure called the Northern Cross, which extends over the Milky Way something more than twenty degrees. The figure serves to identify the star, but it is a rather ill-formed cross and not much more like a true one than the far-famed Southern Cross, which is so impressively described by travellers in southern latitudes and is so disappointing, on first

sight, to the observer who expects accurate rather than suggestive outlines in the constellations.

Deneb is the star at the head of the upright of the cross. In the spring, when it



TRIANGLE FORMED BY POLARIS, DENEB, AND VEGA

rises in the northeast, the cross is almost upside down, and Deneb comes up last. When the cross is setting in the northwest, its position is partly reversed, so that it

seems more nearly upright, and Deneb disappears last.

While this figure is commonly spoken of as the Northern Cross, it is really only a part of

THE NORTHERN CROSS

a larger constellation known as Cygnus, or the Swan, and this is the name used by astronomers in referring to the constellation in which Deneb is found. It was named by the ancient astronomers, and was thought by them to suggest the figure of a flying swan, the out-stretched wings being represented by the stars which form the arms of the cross. The head is marked by the

star at the base of the cross, and in the tail is Deneb. The name "Deneb" means "the tail," and the star gets its name from its position in the constellation. Deneb is sometimes called Arided, an Arabic word which means "the hindmost."

The swan represented by this constellation was supposed to be the one whose form Jupiter assumed when he visited Leda incognito; and having served the purpose of the god, what more natural than that its empty but sacred form should be placed forever in the heavens?

Though there are nineteen other stars (fourteen in our latitude) that seem to us brighter than Deneb, it probably exceeds most of them in size and would hold a much higher rank as to brilliancy if it were as near as some of the brightest of the stars. Its distance can scarcely be said to be known, though some astronomers believe that at least approximate measurements of it have been secured. If these measurements are correct, they show that the star is so far away that its light cannot reach us in less than three hundred and twenty-five years, and it may take even longer than that. This means that it is so many thousands of

millions of miles away that if its distance were expressed in figures they would mean more than the mind can grasp.

Deneb is white in color and is of the same class of stars as Spica and Vega, being in an early stage of its existence as a glowing star. The spectroscope shows that at present it is approaching us at the rate of about thirty miles a second.

Deneb, like Capella and Vega, can be seen at some time between sunset and midnight every night in the year. It is closely associated with Vega as an ornament of the sky, because they adorn the same portion of the heavens at the same season. Following almost in the wake of so dazzling a star as Vega, Deneb may at first excite less interest and admiration than is its due; but a closer acquaintance with its sparkling face will show that its beauty is no more eclipsed by Vega than the low nodding anemones are eclipsed by the splendor of the magnolias. They each have their own individual charm.

Deneb arrives at the spring gathering in the east an hour later than Vega, but, being farther north, it pursues a longer course, and, coming leisurely to the western sky, it

lingers in our view each day for three hours after Vega has gone. Deneb is particularly attractive in this part of its path during the early evening in January and February. It is then rather low in the northwest, and with Vega gone and no other bright star very near, it has a more commanding charm. In the heavier atmosphere, which induces a more rapid twinkling, the star seems to take on an accession of gayety and goes fairly dancing down behind the horizon, where it finishes its circle and appears again in the northeast about four hours later.

Deneb rises just after the sun sets about the middle of May and sets about an hour after sun-down during the early part of March.

Inasmuch as Deneb is so far distant, it is interesting to know that in the same constellation (Cygnus) and not many degrees east of Deneb, or below it as it rises, lies a star famous as being the first star whose distance from us was measured. It is but little more than seven light years away, and until the nearness of Alpha Centauri was discovered, it was supposed to be the nearest to us of all the stars. Two others are now known to be nearer. This little star has no

name of its own, and is known only as 61 Cygni, its catalogue designation. It is not much more than visible to the naked eye, but can be seen by a keen eye on a clear night. Its position is marked on the diagram of the cross on page 58.

The star at the foot of the cross, or in the beak of the swan, as one chooses to figure the constellation, is Albireo, a fine double star. It is easily resolved into two stars by a small telescope and is notable on account of the strong contrast in color between the two stars composing it. One is a deep blue, and the other a bright orange.

VIII

ALTAIR

A LINE about eighty degrees in length drawn from the pole towards the south and running about half-way between Deneb and Vega will point to the brilliant white star Altair. It is almost twenty degrees directly south from Albireo, mentioned in the last chapter as marking the base of the Northern Cross. It lies just at the edge of the Milky Way; and, for any one who has learned the position of Deneb, it will be easy to find Altair by running the eye down the Milky Way from Deneb along the upright of the Cross to Albireo at the foot of it, and thence on twenty degrees, or to the first very bright star, which will be no other than Altair.

The constellation in which Altair is situated is known as Aquila, or the eagle; and Altair is the middle one of three fairly bright

stars placed with reference to each other in a straight line.

The lines between Altair and Deneb and Vega form an acute-angled triangle with the

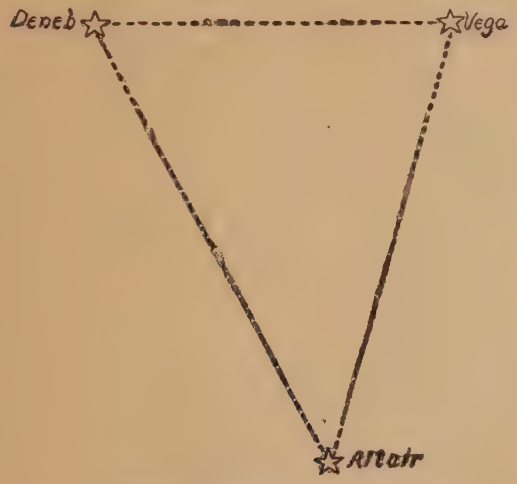
ALTAIR AND ITS TWO COMPANIONS

short side towards the north and Altair at the apex at the south.

Altair rises about eight degrees north of the exact eastern point on the horizon and about ten degrees south of the spot where Arcturus first appears. It is the only very bright star in this region of the sky, and there will be no trouble in identifying it. One of the interesting figures which serve to mark the locality is a small diamond-shaped cluster formed by four stars lying about ten degrees northeast of Altair.

This cluster is known sometimes as Delphinus, or the Dolphin, but more popularly as "Job's Coffin." Why the figure should suggest a coffin rather than a dolphin, it is not easy to see. It can hardly be said to much resemble either object.

Among the stars of the northern hemisphere, Altair is the first bright star to claim



DENEB, ALTAIR, AND VEGA

our attention in the east after Vega and Deneb have made their brilliant close to the gathering of the stars of spring. Capella is

within two hours of setting in the northwest, Arcturus is nearing the highest point in his course across the heavens, Spica has reached the meridian, and Vega is about half-way

THE DOLPHIN, OR JOB'S COFFIN

up to the zenith, when, on the first of June, between half-past eight and nine o'clock in the evening, Altair makes its gracious entrance into the starry company. With one exception, it is the most attractive of the stars that rise during the early evening in summer. By the middle of the first summer month there is a lull in the noisy rush of the on-coming season. The dazzling blossoms

of the fruit trees are scattered and almost forgotten, while the tiny green outlines of the fruit are quietly swelling towards their perfect form. The leaves on the forest trees have assumed their proper shape and are gradually expanding to full size. The old-fashioned annual roses are in their fullest glory. The blue jays have become stealthy and quiet; and most of the birds, while still in full song, have given over the frolicsome hilarity of the spring for the serious work of the nesting-time.

Then there comes a soft June evening, with its lovely twilight that begins with the last song of the wood-thrush and ends with the first strenuous admonitions of the whip-poorwill; and, almost as if it were an impulse of nature, one walks to the eastern end of the porch and looks for Altair.

It is sure to be there smiling at one just over the tree-tops, with a bright companion on either side, the three gently advancing in a straight line as if they were walking the Milky Way hand in hand and three abreast.

From this time on until the first half of December is past, Altair is in view early in the evening. Always an attractive star, it is never more charming than it is along in

September and October. It is then due south from us and at its highest point, which is about two-thirds of the way up from the horizon to the zenith, and this favorable position, added to the peculiar clearness of the autumn sky, brings out all the soft beauty of the star.

One seldom sees Altair during the first four months of the year. Along in the very first days of January a prompt lookout and a clear sky will yield a glimpse of it between sunset and seven o'clock; but it is soon lost in the glow of the rapidly lengthening days. In February, March, and April the very early riser and the belated watcher after midnight may see the star rise, and in May, as the month progresses, it becomes a more and more familiar figure in the east.

There is nothing spectacular in the advent of Altair, and one does not watch for it with the same eagerness that he feels when Arcturus and Vega are nearly due. It comes gently into sight, and almost before one realizes it the star has become a part of the evening view. Arcturus and Vega suggest the bustling coming of spring. The quiet approach of summer reminds us that Altair is here.

It requires about thirteen hours for Altair to pass from its rising to its setting; six hours and a half to reach the meridian, and six and a half more to finish its diurnal course. Remaining so low in the sky as it does, one can see it and yet remain in a comfortable posture during its entire passage across the heavens. This adds greatly to its charm; for any star is, in itself, most beautiful when it is in the highest and clearest part of the sky. It is the difficulty of seeing it there which detracts from our pleasure in it. One cannot come into any great fondness for a star that he sees only by snatches. The stars that we love best are the ones into whose faces we can look for an hour at a time, if our fancy so leads us. It is truly star-gazing that brings us into any great delight in a star.

As to its physical development, Altair belongs in the same class of stars as Vega, Deneb, and Spica. It is still young, and tenuous, and far from having reached that point in its career which begins the path downward to solidification and darkness. Though the sun gives to us almost ninety billion times as much light as Altair, the star really sends abroad nearly ten times more

light than the sun. Its nearness to us is all that makes the sun so much brighter.

And yet Altair is not one of the far distant suns, but is comparatively near us. It is less than four times as far away as the nearest star and sends its light to us in about fifteen years. The star itself is approaching us at the rate of about twenty-seven miles a second, or more than eight hundred millions of miles a year. Yet even with this marvellous speeding towards us, and in spite of its comparative nearness, considerably more than a hundred thousand years would be required for Altair to reach the place in the universe that is now occupied by us.

IX

ANTARES

ABOUT ten o'clock in the evening of the longest day in June is, perhaps, the most favorable time to look for Antares—a beautiful star in a beautiful constellation. It is then due south and at the highest point in its diurnal path across the heavens, which never takes it higher than a little more than one-fourth of the way from the horizon to the zenith. A line about one hundred and sixteen degrees long drawn directly south from Polaris and passing just half-way between Arcturus and Vega will point it out, lying in the heart of the constellation Scorpius, which is flung out over the southern sky in a fine sweep that wins admiration from the most casual observer.

Antares is also indicated by a line drawn at right angles to the line connecting Altair and its two companions and extended about

sixty degrees, or to the first brilliant red star, Antares, the only one of its kind in this most interesting region of the skies. An

SCORPIUS

almost equal-sided triangle about fifty degrees long on each side is formed by the lines connecting Antares, Vega, and Arcturus, which is a still further guide to the location of the star.

Antares is one of the southern stars, which, as has been explained, are the stars that lie south of the celestial equator, no matter whether they are visible to us or not. It is, with one exception, farther south than any other of the very bright stars (stars of the first magnitude) that can be seen in our latitude. It rises in the southeast and has so short a course over which to pass, in our view, that it reaches the half-way point, or the meridian, in about four hours and a quarter.

Antares comes into view two hours and a half later than Vega, an hour and a half later than Deneb, and nearly an hour earlier than Altair. But it is so much farther south than Altair that it seems more aloof from us and it scarcely emerges from the hazy lower atmosphere until Altair is shining gayly and has already become one of the important figures in the eastern summer sky.

While the latter part of June and all of July are perhaps the best times to see Antares at its brightest, it is an interesting star to observe much earlier in the season. If one has an unobstructed view of the southeastern sky down almost to the horizon, he will note the appearance of Antares as early as the middle of May between nine and ten

o'clock in the evening. Before one has really seen the star, he becomes conscious of a ruddy glow low in the southeast that at once fastens the attention. It is the face of Antares, whose red light shining through the heavy atmosphere is so diffused that it gives a rosy effect to the sky for a considerable distance around the star, like a miniature presentment of the sun as it rises on a hazy morning. This is all the more noticeable because it is so in contrast with the usual colors of early May. They are all of the more delicate and colder sort, from the pinkish-lavender and white of the young leaves that shimmer over the landscape to the pinkish-purple of the sky and the dazzling white and blue of Deneb and Vega and a few other stars that belong particularly to this season.

The fact that Antares, when it is visible at all, is always so low in the sky and so clearly before our eyes when they are turned towards the south, makes it a constantly conspicuous figure in the heavens during its entire stay. It is fortunate that this is so, for the stay of Antares is short. It is visible in the evening between sunset and midnight for only six months, and during only one of these months (June) is it visible all night.

In November and December and most of January it is above the horizon only in the daytime, and in February, March, and most of April it is not high enough to be clearly visible until after midnight. In the early part of June it rises just as the sun sets.

I am not sure that the color of Antares is any reason why it should be associated with the blooming of red flowers; but I find in my journal of out-door things that I have unconsciously made the association. One entry, on June 30th, says: "Antares is shining splendidly to-night and rivals in color the wild red lilies that were blooming to-day in the coppice down beyond the spring." Another entry, on August 5th, says: "We found the first cardinal-flowers to-day," and a little farther on, "Antares is almost as red as a cardinal-flower to-night." It is certain that the wood lilies bloom when the star is at the culmination of its summer glory, and the cardinal-flower sends up its flaming stalks when the star is speeding after the sun and sets about midnight. Its bright red color, too, is accentuated when Antares is near the setting-point in the southwest, just as when it was rising in the southeast.

Although Antares is almost strictly a summer star, it is a very significant object in the southwestern heavens during September and October and is often commented on at that time by persons who have not noticed it earlier in the season. The dark background of the autumn sky throws the flaming face of the star into relief, and its redness is still further intensified by the white sweep of the Milky Way, which is then very bright and which lies within a few degrees of Antares.

The constellation of which Antares forms a part (Scorpius) represents the scorpion which stung Orion, and it is the "hissing snake" from which Spenser represents Orion as "flying fast." The two constellations are so placed in the skies that Orion dips below the western horizon just as Scorpius rises in the east, and the mighty hunter does not return until the Scorpion is gone. They can never be seen at the same time.

The color of Antares indicates that it is an old star, far advanced in its development, and, being so, it does not give out as much light as it did in the earlier stages of its existence. But with all its waning, it still gives nine hundred times as much light as the sun, and hence must be an enormously large and

brilliant body. It is one of the very remote stars, requiring more than one hundred and sixty-two years to send its light to us.

Antares is one of a binary system. Its companion is remarkable for its color, which is a bright green and forms a strong contrast to the scarlet light of the larger star. The companion can be seen with a moderately small telescope, being only two degrees fainter than stars that can be seen with the unassisted eye.

X

FOMALHAUT

STILL lower in the southern sky than Antares and in a comparatively starless region shines Fomalhaut, the lonely, the eighteenth star in point of brightness among all the stars in the heavens and the thirteenth among those that can be seen in our latitude. It is so completely isolated from other bright stars that it needs no line to especially point it out. But if the line which leads from the pointers to the Pole Star were extended beyond the pole and on directly south about one hundred and twenty degrees, it would end near Fomalhaut. This will be an easy line to trace during the months when Fomalhaut is visible, for the pointers will then be shifting from a position west of the pole to one directly under it, and the line will have a free path across the heavens. The star may be easily recognized without any other description than that it is at the

end of a zigzag line of small twinkling stars which runs across the southern sky in the autumn and points unmistakably to Fomalhaut. The small stars represent the stream of water that Aquarius is pouring from his urn. The stream runs to the constellation known as the Southern Fish (*Piscis Australis*), and Fomalhaut marks the mouth of the fish.

There is a calm dignity about this star that lends much interest to it. It comes

FOMALHAUT

gently into view far down in the southeast in August, but with so little of a flourish that one scarcely notes its presence until along in early September. Then, when the days are growing shorter, some evening, just after dark, one sees it, a conspicuous, impressive object serenely trailing along over the small

arc of its circle in the south with no companion near it, and, apparently, no need of one to add to its splendor.

On early acquaintance the loneliness of the star, added to the sombre signs of approaching autumn, sometimes gives one a touch of melancholy. But its aspect when more familiar soon comes to suggest only sweetness and serenity, and a lover of Fomalhaut feels that a sustaining light has gone when, during the last of December, this beautiful star sinks gently down in the southwest and disappears from the evening sky not to return for more than seven months. One loves to think that during these seven months Fomalhaut is making a lonely but majestic sweep high in the heavens of the southern hemisphere: a sweep something larger than Arcturus makes in our skies.

Fomalhaut and Capella rise at almost exactly the same minute; but the path of Fomalhaut across the sky is so short that it has finished its course and gone from view for more than two hours and a half before Capella has reached its half-way point, the meridian. Rising together as the two stars do, one seeks to continue some close association between them; but they have nothing

more in common. In the course each has to run and the joy each has to give they are as widely divergent as two royal babes born at the same moment on different sides of the globe.

Fomalhaut is one of the four "royal" stars of astrology. The others are Regulus, Antares, and Aldebaran.

Only eight hours are required for Fomalhaut to pass from rising to setting, and at its highest it is never quite one-fourth of the way up from horizon to zenith. It is the farthest south of any very bright star visible in our latitude.

Fomalhaut is distinctly a star of the autumn. When it first appears in August the nights have already begun to grow longer, the birds have ceased to sing and are seeking the deeper shadows of the woods in which to shed their summer suits, and the quiet of autumn is everywhere stealthily creeping upon us. At the time of the equinox, in September, the star rises about an hour after night falls and is on the meridian between ten and eleven o'clock in the evening. About the middle of October it rises as the sun sets and shines until two o'clock during the first white frosty nights. In November and

December, when even the most hardy insects have stopped their shrill notes and the winter stillness has fallen upon us, a glance towards the southwest will discover Fomalhaut, still placid and alone, on its way to adorn the warmer southern skies, its serenity in no wise disturbed and its beauty in no wise eclipsed by the more spectacular entrance of the brilliant winter stars now gathering in the east.

Notwithstanding that to our view Fomalhaut is eclipsed in brightness by seventeen other stars, it actually gives out twenty-one times as much light as the sun. While not one of our nearest neighbors among the stars, it is still not so very far away, for its light reaches us after a journey through space of only twenty-one years. There are only four other stars among the twenty brightest that are known to be nearer to us.

So far as has yet been discovered, Fomalhaut has no companion star. It is not only in a more or less starless region to our view, but its loneliness seems to be actual.

XI

ALDEBARAN

THE stars thus far described have a particular connection with the spring, summer, and autumn months. Capella, it is true, shines throughout the winter; but it can be seen while the evenings are pleasant, and as it is in the most convenient positions for observation in the spring and fall, it belongs, in large part, to the out-door season. There are, however, six brilliant stars that are distinctly of the winter. They are not only of the same season, but they belong in a way together, for they are in constellations that join each other and spread out in a splendid panorama across the southern skies, making the most dazzling display of fixed stars that any part of the heavens affords. They are Aldebaran, Betelgeuse, Rigel, Pollux, Procyon, and Sirius.

Of these six stars Aldebaran is the first to

appear. Along in September, a very little north of east it shows its fiery face above the horizon with such unmistakable individuality that it catches the eye of even the least observing. It appears at a point about thirty degrees farther south than Capella and rises about two hours and a half later than that bright star. But it is hardly less conspicuous, for though its actual brightness is rated nearly a magnitude lower than Capella's, it glows with a rosy light that demands recognition and at once pronounces it one of the most important heavenly bodies.

Aldebaran lies at the lower end of a bright V-shaped cluster of stars known as the Hyades.

THE HYADES

The cluster is in the head of the great constellation Taurus, or the Bull, and the star itself marks the fiery eye of the enraged bull as he lowers his head for a lunge at Orion.

It is difficult to miss finding Aldebaran if one watches in the region indicated, during late September or early October, for the first bright star that rises after Capella. The locality is still more distinctly marked if one chances to know the shimmering light of the Pleiades, which are in the same constellation as Aldebaran and constitute the one group of stars that is usually familiar to the youth who celebrate Hallowe'en. Aldebaran shoots its ruddy face above the horizon just an hour after the hazy little dipper of the Pleiades has appeared and the star is then to the east of, and, hence, almost directly under, the Pleiades. This following of the Pleiades is what gives Aldebaran its name, which means "the hindmost," or "the follower."

Aldebaran shines in the evening skies for about eight months in the year. It becomes a fixed ornament of the eastern sky about the last of September, when it rises between nine and ten o'clock. The ruby Antares has been below the western horizon for nearly an hour when the still brighter ruby Aldebaran comes into view in the east. The two stars can never be seen at the same time and they do not at all resemble each other except in

color. Even in this respect they differ, for Antares is a deeper red than Aldebaran, though not so bright a star. But as one watches the slow sinking of red Antares in the southwest, and gives a sigh of regret when he has entirely disappeared, it seems but a natural association that draws one's eye towards the east to watch with eagerness for ruddy Aldebaran to give that touch of color which the sky seems to lack.

In astrology these two stars were known as "royal" stars, and there is a whimsical suggestion of royalty in them now as the one slips away from our admiring gaze and we turn to hail the coming of the other. "The king is dead! Long live the king!"

In his section of the sky Aldebaran reigns throughout all the lovely autumn evenings, with beautiful Capella in her own realm to the north of him and Fomalhaut far to the south. His near associates are in the bright groups which I have called the winter stars, and they appear in quick succession after him.

From the time Aldebaran first appears until late in December it may be seen in the eastern heavens in the early evening. It rises just as the sun sets near the first of

December and reaches the meridian seven hours later. In January and February, it is at its highest point early in the evening and is then a little more than two-thirds of the way up to the zenith. At the same hours in April it is conspicuous in the western sky, and by the end of May it has disappeared. In June it is above the horizon only in the daytime, and in July it can be seen not long before the sun rises.

Aldebaran is the fourteenth star in order of brightness in the entire heavens and the ninth among those seen in our latitude. It is what is known as a standard first magnitude star. It gives to us about one ninety-billionth as much light as the sun, but at the same distance as the sun we would get from it forty-five times as much light as the sun gives us. It requires something more than thirty-two years for the light of Aldebaran to reach the earth, which means that it is nearly two hundred trillions of miles away. It is increasing this distance at the rate of about thirty miles a second; but even at this rate it will require more than ten thousand years to add another trillion of miles to its distance.

Aldebaran lies in the path which the moon

follows as it crosses the heavens, and is frequently obscured from our view by the moon's passing between it and the earth. Such an intrusion of the moon is called an occultation, and is an interesting phenomenon when the subject occulted is either a bright star or a planet. A star, in such a case, disappears behind the moon instantly, because a star shows no sensible disk. A planet disappears gradually.

Aldebaran has a companion star, which can be seen with a good telescope.

XII

ORION'S BRIGHT STARS

NEXT to the Great Dipper, Orion is probably the most widely known of all the constellations. It contains more bright stars than any other single group, and they exact all the more immediate admiration because they are clustered so closely and symmetrically as to form a set figure of dazzling jewels — a veritable "sunburst" of "diamonds in the sky."

To the ancients this figure, as its name indicates, represented the giant Orion placed in the heavens in heroic attitude facing Taurus, the mighty bull, who, with fire darting from his eye (marked by Aldebaran), is about to make an onset with his splendid long horns. Orion stands with his right arm uplifted and his great club in the air ready to strike. Over his left arm hangs a lion's skin, which he holds up as a sort of

shield before him. With a little play of fancy it is not difficult to see in this constellation a colossal figure, splendidly poised and full of action. Most of the right leg is

ORION

hidden behind a small figure in front of Orion, so that the torso suggests somewhat an un-

restored piece of classic sculpture; but a little imagination can complete it satisfactorily without the sculptor's labor. The diagram on the opposite page shows the figure as outlined by the stars.

Orion not only includes an unusual number of bright stars, but it has the further distinction of being the only constellation visible in our latitude that contains as many as two stars of the first magnitude, or highest degree of brilliancy. These two stars are Betelgeuse and Rigel. Betelgeuse marks the right shoulder of Orion, and Rigel is in the left foot.

The first of these to appear is Betelgeuse. It pushes its red face up over the horizon about an hour and a half after Aldebaran has risen, and is only about nine degrees farther south than Aldebaran. It is of about the same degree of brightness as Altair, but it has not the same cheerfulness of aspect. On the contrary, there is a decided suggestion of sombreness in its dull and comparatively untwinkling face.

The color of Betelgeuse is deep red tinged with orange, a color that marks the least scintillating of the stars. It indicates also that the star has passed its brightest stage

and is gradually approaching the period of darkness. The period of darkness is probably preceded in the life of a star by one of fluctuating brightness, and it is apparently through this period that Betelgeuse is now passing, for it shows to us as one of the variable stars. It passes irregularly from its brightest to its dullest stage of lucidity. Most of the time it equals in brilliancy Altair or Aldebaran; sometimes it is no brighter than Fomalhaut or Deneb. But it always remains bright enough to be a first magnitude star.

About fifteen or twenty minutes after Betelgeuse has appeared Rigel comes twinkling into view. It is the brightest star in Orion and lies about sixteen degrees south of Betelgeuse. The celestial equator runs just about half-way between the two stars; so that Betelgeuse belongs to the northern hemisphere and Rigel to the southern. With Aldebaran, these two stars form a triangle, the sides being from sixteen to twenty degrees in length. Rigel is exactly south of Capella; hence, a line drawn from Polaris through Capella and extended a little more than fifty degrees will end at Rigel.

In point of brilliancy Rigel ranks next to

Arcturus. It is a very bright white star, as dazzling as a small electric light and as sparkling as a fine white diamond. But with all its fair beauty Rigel does not seem as much of a personage in the assemblage of stars as sombre old red-faced Betelgeuse; and in looking at them I am always conscious of feeling a somewhat closer friendliness for Betelgeuse than for Rigel. This, however, is purely a personal fancy.

Rigel is so far away that astronomers have not yet been able to measure its distance. Unless some change takes place in its course or ours, it will never be any nearer; for the spectroscope shows that it is receding from the solar system at the rate of about fifteen miles a second.

As to distance, almost the same may be said of Betelgeuse. It is receding from us a little more swiftly than Rigel, the rate being about twenty-two miles a second; and the measurements of its distance are uncertain, so that it is necessary to allow for a large degree of error. The measurements that at present seem most reliable show that the star is certainly not nearer than one hundred and sixty-two light years. For the brightness it shows at that distance the star must

send abroad at least five hundred times as much light as our sun.

Although Rigel rises about fifteen minutes later than Betelgeuse it sets nearly two hours earlier. This is because it is farther south than Betelgeuse and has a shorter path over which to travel from rising to setting. Betelgeuse is above the horizon for something more than thirteen hours, while Rigel is in view only about eleven.

When on the meridian, Rigel lacks four degrees of being half-way up to the zenith, and Betelgeuse lacks only four degrees of being two-thirds of the way up. The course across the heavens of Betelgeuse corresponds very nearly with that of Altair. The course of Rigel is about the same as that of Spica. Rigel has a companion star, which is a bright sapphire-blue in color. It is only of about the ninth magnitude; but it is difficult to see even with a telescope, because it lies so very near the sparkling Rigel, whose dazzling light obscures the smaller star.

The other bright stars of Orion are hardly less interesting than Betelgeuse and Rigel. Bellatrix, which marks the left shoulder of the giant, is of the second magnitude, but still a very brilliant star. Three dazzling

second magnitude stars form the belt, or girdle, of Orion and lie half-way between Betelgeuse and Rigel. These are the stars supposed to be referred to by Job as "the bands of Orion." They lie in a straight line exactly three degrees long, and are rendered so conspicuous by their position and their intrinsic beauty that they are an aid in finding the constellation. They also serve as a measure for estimating distances in this section of the skies. The upper one of them lies exactly on the celestial equator, and is a fine double star discovered by means of the spectroscope. They are, in fact, all three double stars and probably binary systems.

These three stars are called in some places the "three kings," and the line formed by them is sometimes called the "ell and yard" on account of its being just three degrees long.

Depending from the belt is a curved line of stars known as the sword of Orion. The third one from the bottom is distinctly hazy in appearance, and is no other than the famous Orion Nebula. It is one of the finest nebulæ in the heavens and is one of the few that can be seen with the naked eye. The one star that we see in it resolves through

the telescope into six beautiful stars and forms a figure that is sometimes referred to as the "Orion trapezium."

The fourth star which with Betelgeuse, Rigel, and Bellatrix forms the large parallelogram that outlines the constellation is called Saiph and is situated in the right knee of the mighty hunter.

With all its wonders and its beauties, it is not strange that Orion should be one of the most familiar and most admired of all the constellations. It is in the centre of the galaxy that marches in brilliant procession across the winter skies. We watch for it between nine and ten o'clock in the evening late in October, and our first view is of the curved line of faint twinkling stars that outline the left arm and the lion's skin. Then one jewel after another emerges from the storehouse below the horizon until the whole splendid figure is before us. Its arrival is an announcement that the out-door season is past, that the nights are becoming more and more frosty, and that the gorgeous tapestry with which the autumn hills seem covered will soon fall away and give place to the lovely low tones of winter. We remember then that the juncos came that day and that

we heard them as we crossed the coppice about dusk twittering cheerfully to each other as they settled for the night among the low bushes. And we make a mental note to see to-morrow if the little brown screech owl has moved into his winter quarters in the old catalpa-tree across the road.

During November and December, Orion becomes a familiar figure in the evening skies, rising a little earlier each evening until during the week on each side of New Year's Day he appears in the east just as daylight fades. In February he stands erect in the southern sky at nine o'clock in the evening. In March and April he is rushing furiously down the western sky after Taurus and the Pleiades, and by the middle of May he has disappeared from the evening view. In the latter half of July the very early riser can catch a glimpse of him in the east just before daylight. It was, no doubt, in this month that the "rosy-fingered dawn" took him for her lover, as she is reputed to have done.

XIII

THE HEAVENLY TWINS

ON the old astrological maps the constellation Gemini, or The Twins, was represented by two lusty-looking youths standing in an affectionate attitude with their heads practically consolidated, and each wearing a star as a sort of monocle in the outer eye. These stars are called Castor and Pollux, after the brothers from whose eyes they are supposed to shine. They are the brightest stars in the constellation Gemini, which is outlined by two almost parallel rows of stars beginning at Orion, running northeast about twenty degrees, and ending with Castor and Pollux.

Pollux is the brighter of the two and is the only first magnitude star in the constellation. But it is almost as difficult to consider the two heavenly bodies apart from each other as it was to separate the two

fond brothers for whom the stars were named.

The stars lie only about four and a half degrees apart and are so conspicuously a pair that each serves as an identifying mark for the other. Moreover, Castor has not always been the inferior star in point of brilliancy. Three hundred years ago he was brighter than Pollux, and though in the course of the centuries he has been outstripped in brilliancy by his brother, he has still some points of superior interest, as will be seen later on, and is entitled to be considered with respect and admiration in the gay company of our friends among the stars.

Castor and Pollux enter at the eastern gate of the skies at about the same time that Betelgeuse and Rigel appear, but the Twins are so much farther north that there is no danger of confusing them with the two brilliant stars of Orion.

Betelgeuse and Castor come into view at almost the same moment, the former only about seven and the latter a little more than thirty-two degrees north of the exact east. About ten or twelve minutes later Rigel appears at a point a little more than eight de-

grees south of east, and after an interval of from ten to fifteen minutes, Pollux shines out above the horizon about thirty-seven degrees farther north.

In November, when the twin stars first become a prominent feature of the early evening sky, Castor is leading. When they come to the meridian, about eight hours later, Pollux, being farther south and thus having a shorter course to run, has so gained on his companion that he reaches the meridian only about ten minutes later. At this point, which is their highest, Castor is nine-tenths and Pollux is about seven-eighths of the way up from the horizon to the zenith.

As they descend the western sky Pollux makes a still further gain, and in the latter half of the course they are seen side by side. They are particularly attractive during all of May and the first half of June, when they hang during the evening in the northwestern heavens shining out gently and kindly from the glowing background that the sun has left behind it.

Castor and Pollux were supposed by the ancients to have a favorable influence over navigation, and the figureheads of ships often represented them. The Apostle Paul,

when shipwrecked on the island of Melita, sailed from it "in a ship of Alexandria . . . whose sign was Castor and Pollux," and, of course, had a prosperous voyage to his friends in Rome.

The constellation Gemini is the third spring sign of the zodiac, and it is easy to see how the mere beauty of its chief stars, Castor and Pollux, may have fastened upon it the reputation of responsibility for the beautiful weather that comes early in June. At this season of the year position, atmosphere, and surroundings all combine to enhance the beauty and accentuate the individuality of these two beautiful stars. All, save one, of the radiant stars that have absorbed attention in this region of the sky during the winter and early spring have disappeared. The rainy Hyades, including Aldebaran, were the first to go. Stormy Orion followed soon after, and the ill-omened Dog Star went with him. And now in a comparatively starless environment the twin stars, beloved of sailors, dominate the western sky and shine side by side like two eyes benignly set to keep a protecting watch upon the world. It is not the sailor alone whose fancy is pleased with the kindly vigil they seem to

keep. A landsman, too, may have pleasanter dreams if he will but take a peep through the western window and exchange friendly glances with them before settling down for the night.

Inasmuch as Castor and Pollux are so closely associated in our minds, in their times and seasons and their apparent position in the sky, it may be something of a shock to learn that they are in reality quite independent of each other and that they are going each his own way, in entirely different directions, towards an entirely different goal. To our view they are only four and a half degrees apart. But, in reality, one lies considerably more than two hundred trillions of miles farther from us than the other. Castor is the nearer of the two and is not a very far distant star as stellar distances go. Its light comes to us in a little more than sixteen years, and it is only about one million times farther from us than the sun. It requires more than fifty-four years for the light of Pollux to reach us, and the star is more than three million times as far from us as the sun.

Pollux, however, is approaching us at the rate of about twenty-five miles a second, and

Castor is retreating from us at about the same rate. If indeed they are travelling in exactly opposite directions, it is not impossible to conceive that in some far distant age they may come within reasonable distance of each other. If they do, and if the people of the earth are here to see it, they will behold a mighty sun in Pollux and a telescopic star in Castor. But it would require considerably more than one hundred and forty thousand years to accomplish this change, and the stars would then be about two hundred and seven trillions of miles from us—a distance over which it would take light thirty-five years to travel.

Castor and Pollux are not only thus widely separated, but they are at different stages of development. Pollux is yellow in color and is the same type of star as the sun and Capella—the class known as solar stars. Castor belongs to that large class of stars that includes Vega, Spica, Deneb, and about half of all the stars in the sky. They are usually white, but are sometimes tinged with color, as in the case of Vega, which is tinged with blue, and of Castor, whose tint is green.

Though the bond between Castor and

Pollux is more apparent than real, Castor, at least, has a true companion. The companion is but a fraction more than one magnitude less bright than Castor itself and is greenish-yellow in color. It is bright enough to be seen with the naked eye, but we cannot separate the two stars without the aid of a small telescope because they lie so close together. The distance between them is only about four seconds, or one nine-hundredth of a degree.

The two stars revolve about each other very slowly, and though they were found to compose a double system of stars nearly two hundred years ago, they have not yet completed one full revolution, and their period is not exactly known. It is estimated, however, that it will require probably a thousand years for them to describe one revolution.

The smaller of the two principal stars composing Castor has recently been discovered to have a satellite of its own. A dark star revolves about it with a speed so different from that of the two larger stars that it completes one circuit of its orbit in less than three days. In addition to these three stars, there is another small star near

them that is believed to form a part of the system. Castor, therefore, as we see it, is certainly composed of three and probably of four stars.

To swear by Castor and Pollux was common practice in ancient times, and later the name of the constellation itself came to be used in the same way. In Elizabethan literature we not infrequently find the expression "Oh, Gemini!" which by the modern rustic is corrupted into a slightly different word and gives him the expletive "By Jiminy!"

XIV

THE TWO DOG STARS

A STRAIGHT line from Aldebaran running through the belt of Orion and extending beyond it towards the southeast about twenty degrees will point out the Great Dog Star, Sirius, by far the brightest star in the heavens, and, happily, so situated that it can be seen in all southern latitudes and in all northern latitudes south of Greenland. Next to Polaris it is, perhaps, the best known of any individual star, and this in spite of its not being visible in the latitude of the United States before midnight during the months when people are most out-of-doors and most likely to observe it—from May to November.

Sirius is called the Dog Star because it is the chief star in the constellation of the Great Dog, which follows at the heels of Orion in his journey across the skies. The

constellation gives the name of "dog-days" to the hot and trying period of the summer, including most of July and the first half of August. During this time Sirius rises just after the sun, and following it over the heavens each day, the star was supposed by the ancients to be in some way responsible for the malign heat of the midsummer sun and to exert an evil influence on the health of those exposed to its burning rays. Even now we frequently hear that dogs are likely to "go mad" at this season because "the Dog Star is in the ascendant."

From Homer down to the present day few great poets whose themes were of out-door things have failed to refer to Sirius. A beautifully compact and comprehensive description of the star and its characteristics is given incidentally in the *Iliad*, where Achilles, mad with rage, was first seen by Priam "as he sped across the plain, blazing as the star that cometh forth at harvest-time, and plain seen his ways shine forth amid the host of stars in the darkness of the night, the star whose name men call Orion's dog. Brightest of all is he, yet for an evil sign is he set, and bringeth much fever upon hapless men."

Sirius is the farthest south of any of the bright stars of winter that can be seen in this latitude, and in the sweep over its comparatively small arc in our skies it rises only about fourteen degrees higher than Fomalhaut, the most southern of the important autumn stars, and ten degrees higher than Antares, the most southerly first magnitude star of summer. When Sirius is on the meridian, or at the highest point in its diurnal course from rising to setting, it is only about one-third of the way up to the zenith. It reaches this point about five hours after rising, and, hence, is above the horizon only ten hours out of each twenty-four.

We begin to look for Sirius in the evening sky about the middle of November, at which time it rises about ten o'clock. The real activity of the year is over. No flowers are in bloom save that here and there in some sheltered, sunny spot in the coppice a belated aster is cheerfully swinging its bright blue-starred branches, or some other flower whose season is long past has been enticed by the warm sunshine into showing yet one more blossom. To be sure, the witch-hazel, the very last flower of the year, which thriftily puts forth in the late autumn the bloom for

next year's fruit, hangs full of the curious, straggling golden threads which constitute its flowers; but it stands bare of leaves and its empty seed-cups are open-mouthed as if with wonder and admiration at the success of the explosions by means of which it has lately peppered the neighborhood with its fruit. The heavy frosts have finished the work of painting the hills; the rich brown leaves are fast piling their soft winter covering over the yet warm earth; the smooth clean juncos have been flirting around in merry groups for three or four weeks, and the lovely Indian summer haze hangs like a soft mantle of gauze between us and the half-denuded trees.

In the skies all the others of the bright winter stars have arrived, and some of the brightest of the spring and summer stars still linger to grace the company, when the king of stars arrives. No less than ten of our fifteen brightest stars are in view when the dazzling face of Sirius appears. On the eastern side of the heavens are golden Capella, rose-tinted Aldebaran, red-faced Betelgeuse, fair Rigel, the gentle Pollux, and Procyon, the smaller Dog Star, all fresh and joyous and eager In the southwest is

Fomalhaut, serene and indifferent to what is about to transpire. In the west is Altair, just waiting above the horizon to witness the event and then drop out of sight. In the northeast are Vega and Deneb, bright and gay and twinkling with almost as many hues as Sirius himself.

He comes richly dight in many colors, twinkling fast and changing with each motion from tints of ruby to sapphire and emerald and amethyst. As he rises higher and higher in the sky he gains composure and his beams now sparkle like the most brilliant diamond—not a pure white, but slightly tinged with iridescence. It is worth enduring the chilliness of a clear, mid-November night at ten o'clock to see the assemblage of these eleven noble stars with their attendants. For mere brilliancy it is surpassed at no other season of the year.

The color of Sirius has been the subject of much research by certain astronomers. While it is now in the main white, some references made to it in ancient literature indicate that eighteen hundred or two thousand years ago it was red; and, as a result of learned inquiry, this is stoutly maintained by some astronomers to be true. But in-

quiry on the other side, perhaps equally careful, shows that it could not have been red at that time, and that any word so characterizing it probably meant only "fiery," "blazing," or something of that sort. On the whole, there seems to be no sufficient reason for believing that it has been red and has changed color within any measurably limited period, though it may be so. Some persons maintain that it is even now changing color and becoming red as it was claimed to be in former times. The changes in hue when near the horizon are due to its brilliancy and the special effect of the atmosphere on such extreme brightness.

On Thanksgiving evening, which so often marks the first cold "snap" of the season, Sirius rises about nine o'clock. On Christmas evening it becomes visible a little after seven, and on New Year's about half an hour earlier. About the twenty-eighth of January it rises just as the sun sets, not far from five o'clock.

Being so low in the sky, it is easily observed at any point in its course. Except for the first thrill of pleasure that it gives when it appears in the late autumn, Sirius is never more attractive than during March

and April. It is then at its highest during the early evening and shines brilliantly in the southwest. It sets with the sun about the twentieth of May, and for some days before that it has been invisible, its light being lost in the rays of our own great orb.

As to development, Sirius is in the same class of stars as Vega, Spica, Deneb, and more than half of all the stars, being in almost the earliest and most gaseous stage of existence as a star. It is a typical star of its kind, and the class is named for it. All such stars are said to be Sirian stars.

Sirius is one of the stars that we know to be comparatively near to us. There are only four others that are known to be nearer. Light travels from it to us in about eight years and a half, which means that it is about fifty-one trillions of miles distant, or more than five hundred thousand times farther away than the sun. We get from the star only one seven-billionth of the light that the sun gives us; but Sirius in reality gives out about forty times as much light as the sun. It is a very gaseous and expanded body, however, and though very much larger and more brilliant than the sun is comparatively

light in weight, its mass exceeding that of the sun only about three times.

Sirius has a very interesting companion, which revolves around it in something more than fifty years. Its orbit is such that the two stars are nearer together at one time than at another, and it is only when they are farthest apart that the companion can be seen, and even then a strong telescope is necessary. When at their nearest, the companion is so completely lost in the brilliant light of Sirius that it cannot be found at all. The existence of such a companion had been long suspected, but it was not actually discovered until 1862, a year when the distance between the stars was increasing. Since then they have had a period of being too near to each other to be separated; but they are now getting farther apart, and about 1916 will be at their greatest distance from each other. The companion is a dull yellow in color, is heavy in proportion to its brilliancy, and is probably approaching the stage wherein its light will be practically extinguished. Sirius now gives about ten thousand times as much light as its companion.

The other Dog Star, Procyon, lies in the constellation of the Little Dog (*Canis Minor*).

It may be found by running a line a little more than twenty degrees northeast from Sirius, or about the same number of degrees east from Betelgeuse. Procyon, Sirius, and Betelgeuse are at the angles of an almost equal-sided triangle, and the same three stars form with Rigel a figure which is almost a square. Procyon is twenty-three degrees directly south of Pollux and forms a triangle on the north with Pollux and Betelgeuse of just about the same size as the triangle it forms with Betelgeuse and Sirius on the south. It rises an hour and a half later, and sets an hour and a half earlier, than Pollux.

The name Procyon means "before the dog," and the star was given the name because it appears in the east from fifteen to twenty minutes before the Great Dog Star. It rises very little north of the exact east, reaches the meridian about six hours and twenty minutes later, and sets between two and three hours after Sirius. At its highest point it reaches about three-fifths of the way up to the zenith.

Procyon suffers somewhat in reputation by reason of its connection with Sirius. The fact that it is known as "the other Dog Star" and "the Little Dog Star" indicates inferiority

of some sort. It is, in fact, a most beautiful star, and is only the sixth in order of brightness among the stars seen in our latitude. It is very distinctly individual, being the only one among the beautiful group of winter stars that is lightly tinged with yellow. It is one of the Sirian class of stars, but is somewhat farther developed than Sirius and is beginning to have the golden tint which signifies that it is approaching the time of life into which Capella and the sun are well passed. Occupying this half-way place, it is sometimes called a Sirian-solar star.

Procyon is also one of the near-by stars, but it is not so near as Sirius. Light travels from it to us in a little more than ten years; so that the star is not more than sixty-five trillions of miles away from us. It gives out at least eight times as much light as the sun, and is in no sense an insignificant body or one to be known only as a companion star to Sirius.

Procyon also has a companion of its own, a yellow star of about the twelfth magnitude, which revolves around it in about forty years. It has some points of resemblance to the companion of Sirius: it gives com-

paratively little light in proportion to its mass, it can be seen better at one place in its orbit than another, and the length of the period in which it revolves around its primary is not very different. The companion of Procyon was not discovered until 1896.

XV

REGULUS

THERE is no single line by which Regulus can be exactly pointed out to one who does not know the constellations. Still it can be easily found. A line forty degrees long drawn through the pointers backward—that is, away from the North Star—will end just a little to the west of a conspicuous group of stars known as the Sickle (and really resembling that instrument), and Regulus is the brilliant which sparkles at the end of the handle.

In June and July, when Antares and Spica are both shining, Regulus may be found by a line drawn from Antares through Spica and extended about fifty degrees. The line will unmistakably indicate Regulus, but the star will be well down in the west and not far from setting. When Arcturus is visible and not too far down in the west, Regulus may

be found at a point about sixty degrees west (a very little north of west) of Arcturus. A triangle is formed by Spica, Arcturus, and

THE SICKLE

Regulus, with Regulus at the acute angle pointing towards the west.

Among the brightest stars, Regulus comes and goes rather between seasons. It is not strictly a summer or a winter star, though it may be seen in both seasons. It is, in fact, visible at some time between sunset and midnight for eight months in the year. It comes after the galaxy of brilliant winter stars are in full swing across the heavens and before the gay company that gladdens our view in the spring has begun to assemble.

It appears above the horizon a very little north of east about nine o'clock in the evening of New Year's Day. One may even have seen it a little later in the evening than this some days before Christmas; but Regulus has not that insistent quality of brightness which is largely the result of size, and it does not command the regard of the ordinary observer until it has reached a position and an hour when one can observe it conveniently.

From the time it first attracts our attention until Arcturus and Vega come, Regulus is the chief ornament of the eastern skies and shines like a veritable diamond of the highest quality, fit to be set in the jewelled hilt of sword or scimeter of fine Damascus steel rather than the handle of a homely garden implement. It is a singularly clear, white, sparkling star; but in spite of its brilliancy it seems a much smaller point of light than many of the bright stars. It is next below Deneb in its rank among the stars as to brightness, and the two stars are so nearly equal that some astronomers give Regulus the higher place. In the Harvard Photometry it ranks fifteenth in order of brightness among the stars visible to us, and twentieth among all the first magnitude stars.

It requires about six hours and three-quarters for Regulus to reach the meridian, and it is then about one degree more than two-thirds of the way up to the zenith, or the point exactly over our heads. It shines all night in January, February, March, and April, rising in February just as the sun sets. In May, June, and July it may be seen travelling towards the western horizon during the first half of the night. By August it is so near the sun that even with a favoring atmosphere we can barely get a glimpse of the star during the first few days of the month, as it falls below the horizon close after the sun; and it remains in this region most of September. In the early morning hours of October and November it may be seen gradually gaining on the hours until it comes back to its familiar place in the east.

In point of development Regulus belongs in the class of stars of which Vega, Deneb, Spica, and Sirius are conspicuous examples: very tenuous, perhaps gaseous, bodies, shining with dazzling brilliancy, and giving off more light in proportion to mass than stars of a darker hue.

Regulus is, however, one of the very large suns of the universe. It sends out a thou-

sand times as much light as our sun, and its distance from the solar system is so great that we do not receive the light from the star for more than one hundred and sixty years after it has started towards us, moving though it does at the rate of six trillions of miles a year. This tremendous distance is constantly increasing, though the rate of increase is comparatively small; for Regulus is receding from us at the rate of about fifteen miles a second, which means that the distance between us and the star is increased each year by nearly five hundred millions of miles.

Regulus is in the constellation called Leo, or the Lion. The blade of the Sickle marks the shoulder of the Lion, and Regulus lies at its heart. The star is sometimes called "Cor Leonis," meaning "the Heart of the Lion." The name Regulus means "chief."

The constellation Leo is one of those through which the sun passes in its apparent annual path across the heavens. It is in this constellation a little more than five weeks, entering it at the beginning of the second week in August. Two weeks later the sun passes Regulus, and as the star lies almost exactly in the path of the sun, they

would seem to an observer on the earth to almost touch each other. But at this time the light of Regulus is lost in the sun's rays, and we do not see this interesting meeting.

Another interesting star in Leo, though not of the first magnitude, is Denebola. It marks the tuft at the end of the Lion's tail, and its name means "the Tail of the Lion." It lies about twenty-five degrees east of Regulus and a very little to the north of it. It is the brightest star in a small triangle which a glance towards the region indicated will reveal.

Within the curve of the blade of the Sickle is the point from which the meteors that come along in the middle of November seem to radiate. They are on this account called "Leonids."

XVI

THE NUMBER OF THE STARS

ON a clear starlit night the sky seems so thickly set with stars that, on first view, it is difficult to believe that within two hours one could count every one of them. Yet this is true, for to the ordinary eye there are not more than a thousand stars visible at one time. The very keenest eye without mechanical assistance cannot discern in the heavens, north and south, more than seven thousand, and barely five thousand are visible to the ordinary sight. Of this entire number nearly one-fourth are too far south to be seen at all in our latitude; and of those that can be seen here only one-half are visible at once, the others being below the horizon and visible only in the other hemisphere. And, finally, of those that are really above the horizon and could otherwise be seen, the bright stars are somewhat obscured by the dense at-

mosphere while near the horizon, and the faint ones are completely blotted out for a considerable distance farther up. This is why there seem to be no faint stars low down in the sky. In reality they very largely outnumber the bright ones in every part of the heavens, but they can only be seen when they rise high enough to escape the heavy lower atmosphere.

The stars that we can see with the naked eye (astronomers call them lucid stars) are, of course, a very small proportion of the total number of stars in the universe. As to what the total number is, astronomers do not agree; but it is generally believed among them that there must be at least hundreds of millions. The largest telescope shows nearly a hundred million. Some contend that the number is infinite. The fact that the authorities are not in accord shows that no one is yet able to say absolutely what the extent of the universe, and hence the number of the stars, is. The point of main interest is that the number is probably not infinite. That it cannot be definitely stated is not so important. When the number is so vast, a few hundred millions more or less add no deeper meaning to the general fact.

The difference of opinion among astronomers as to the limitation of the stars is based in part upon their ideas of the destructibility of light. It is certain that we do not get an infinite amount of starlight. If we did, all space, they say, would be filled with a diffused glow and there would be no such thing as darkness. For it is not necessary that we should actually see the stars in order to have light from them. Those that we can see with the naked eye give only about ninety per cent. of the total starlight received by us. The naked-eye and the telescopic stars combined give only about one one-hundred-and-eightieth as much light as the full moon. But on a bright starlight night the light we receive is equal to about one-sixtieth of full moonlight, which shows that we get three times as much light from the stars whose rays are too faint to be seen as from all the other stars together.

It has been shown by photography that we get light from stars that even the largest telescope has not discovered. The photographic plate is so sensitive that, if it is exposed to their rays long enough, it will record the existence of the faint and far-off

stars that eye and telescope combined have no power to discover. But these stars must be giving us light, for they would make no impression on the photographic plate if their light did not reach it.

If there is anything in far-off space that so dissipates light that it becomes lost (and some authorities think that this may be so), then the number of the stars may be infinite. But we can perhaps never know it to be infinite; and practically we need not take much account of the question. It is almost so, too, with regard to certain bodies in space which, for want of a better name, we speak of as dark stars: that is, stars that give no light. We know that there are such bodies, and it has even been suggested by some astronomers that they probably outnumber the stars whose light we see. But we do not take them into account in numbering the stars, for they are known to us only by their influence on other bodies through the laws of gravitation and of light. They make themselves known in some instances by passing at regular intervals between us and a bright star, thus showing that they are revolving around it; and sometimes by making the star swerve from what its course would

naturally be, thus showing that some unseen body is influencing it. As we know more of the stars in general we may come to know more of those that do not shine. They may even become sufficiently known to be classified and numbered. But at present they need not be taken into account.

The telescope and camera both give evidence of a limit at least to the number of the stars that we can really know. As telescopes were made larger and larger a greater number of stars became visible; and it seemed as if the number we could see depended solely upon the power of the glass. It has been found, however, that beyond a certain point the number we can see does not increase in proportion to the increased size of the telescope. This indicates that we must be approaching the limit of the number of stars that send their light to us. The same thing is shown by the camera. After a certain length of exposure no additional time will add more than a few stars to the number already on the plate.

There are about twenty well marked degrees of brightness in the stars seen through the largest telescopes. For the first ten or twelve of these the number of stars in each

grade is about three times greater than in the grade preceding it in order of brightness. That is, we have of the first degree of brightness about twenty stars; of the second degree, sixty; of the third, one hundred and eighty, and so on. But after about the twelfth degree of brightness the number of stars does not increase in the same proportion; the increase as shown by both the telescope and the camera is comparatively small.

It is not to be supposed that, because telescopes and the camera have not yet revealed them, astronomers think there are no more stars to be discovered. To those who believe that light is in no way absorbed in passing through space, there seems to be every scientific reason for believing that there is a limit to the total number. But the evidence of the telescope and photography only shows that we are approaching that limit. The exact number will probably never be known. Almost certainly it will never be known by means of the telescope; for we seem to be reaching a point where it will be physically impossible to make larger telescopes that can be effectively used. The last extension of our knowledge of the number of the stars will probably be reached

through photography. What is not recorded on the photographic plates of the future will remain to us unknown. We can only be reasonably sure of one thing: and that is, that, in view of the evidence we have of the decrease in the number of the stars as they grow fainter to us, the ones remaining undiscovered are practically but a few stragglers along the "fringes of the visible universe,"—few, even though there may be really many thousands of them. And if there are still an infinite number whose light is extinguished in far distant space, they are not to be reckoned as among the number of stars in our universe.

While the number of stars that are known is increasing somewhat all the time, astronomers are not so much trying to make discoveries of larger numbers as to learn something more about the stars that are already known. The number now classified and catalogued is something near eight hundred thousand. But a great international photographic chart of the heavens is at present being made, which, when finished, will show perhaps something near forty millions; and to this there will probably be no occasion to add anything for many years.

XVII

THE NAMES OF THE STARS

HAPPILY for the interest of the ordinary observer, nearly all the brighter stars, and a few of the fainter ones, have individual names. Sixty or more of these names are in common use even among professional astronomers. A few more are well known and are used occasionally, and a number which are now practically obsolete are found in old catalogues, or historical lists, or in some piece of ancient literature. Less than a hundred names will cover all the stars of the first and second magnitudes; and besides these there are not many that have an individual interest for an observer without a telescope. When one learns to know fifty or sixty stars so that he can always recognize them and call them by name, he begins to feel that he has a pretty large acquaintance in the heavens; and the knowing of other individ-

uals that may chance to interest him is then the mere matter of an introduction.

All of the individual stellar names originated with the ancient astronomers, and most of them have a meaning which describes some characteristic of the star; some trait, or color, or position in the constellation. All of them were probably descriptive at first, but the original meaning is not always clear. Sometimes designation was made by a circumlocution such as "the Heart of the Lion," "the Eye of the Bull," "the Foot of the Giant." This was, of course, too cumbersome and limited a method to answer the needs of modern astronomy. But many Latin and Arabian names are still used which in one word describe the place the star holds in its constellation; as, for instance, Achernar, meaning "the End of the River"; and Denebola, "the Tail of the Lion."

Very early in the seventeenth century the plan was adopted of designating the stars in each constellation by the letters of the Greek alphabet and adding the name of the constellation in its Latin form in the genitive case, thus making the name of the constellation a sort of family name for all the stars

composing it, and the Greek letters the given names. Thus in the constellation Taurus we have Alpha Tauri, meaning Alpha of Taurus; Beta Tauri, Delta Tauri, and so on. When the Greek alphabet was exhausted, the Roman letters were used. Beginning with alpha, the stars of each constellation were named in the order of their brightness. In the main, though, when several stars in the constellation chanced to be of nearly the same degree of brightness, there seems to have been no nice distinctions made between them.

A century later another catalogue was made, and in this numbers were used instead of letters for the given names, the genitive case of the constellation still being used as a family name. Several special catalogues have been made in which also the stars are indicated by numbers, such as Lalande's, the British Association Catalogue, and Harvard Photometry. In such cases the reference is simply by number and name of catalogue. Some stars that have in a way become famous by reason of some individual peculiarity or characteristic still have no designation except by number. Among them, and spoken of more particularly elsewhere in this book, are 21,185

Lalande, 1830 Groombridge, and some others. Stars are also designated by their position in the heavens, which is expressed in the terms of astronomical measurements, right ascension and declination.

A result of these various methods of naming the stars is that nearly every bright star is designated in several different ways: by its individual name, its Greek letter name, its number in the various catalogues, and its position in the heavens. But the ordinary observer need not much trouble himself with learning them all. One can have an intimate knowledge of nearly all the naked-eye stars without once resorting to figures for names, or without even knowing what right ascension and declination are. It is only for their own special needs that astronomers have evolved these several schemes of designation. It is so rare a case when a star known only by its number has become, for any reason, of general interest, that it will not offer any difficulty. There are not now more than half a dozen such stars. Probably 61 Cygni (that is, the star numbered 61 in the constellation of the Swan, or Cygnus) is the best known of these, because it is the first star whose distance from us was

measured, and it was until recently supposed to be nearer to us than any other star in the northern hemisphere. Despite its nearness, however, it cannot ordinarily be seen with the naked eye, and so is more of a name than an individuality to us.

The method of designation most common among writers on astronomy for the brighter stars (when the individual name is not given) is that of the Greek letter joined to the name of the constellation. After the constellations are once known, this is an easy method, and, especially for the non-professional observer, has several advantages. It not only names the star, but assigns it to a constellation, and gives an approximate idea of its degree of brightness as compared with other stars, and particularly as compared with other stars in the same constellation. Alpha of a constellation is almost always the brightest star in the group. The exceptions to this are few and mainly accidental. One instance is that of Castor and Pollux, the two bright stars of the constellation Gemini, or the Twins. Pollux is the brighter of the two, yet Castor is Alpha Geminorum and Pollux is Beta Geminorum. This came about, it is thought, through the fact that Castor

has diminished in lustre within the last three hundred years.

It is not often that the average reader will care, or need, to know the names of more than the seven or eight brightest stars of a constellation, the ones designated by the first seven or eight letters of the Greek alphabet: alpha (α), beta (β), gamma (γ), delta (δ), epsilon (ϵ), zeta (ζ), eta (η), and theta (θ). Rarely, indeed, will he care to know even that many. In the Great Bear (*Ursa Major*) the seven brightest stars, the ones that form the well-known Dipper, are of almost equal importance and brilliancy. But this is an exceptional case, and more often only three or four stars in a constellation, the alpha, beta, gamma, and delta of the group, have any special interest. Occasionally one of the fainter stars calls for particular attention, as in the case of Mira, the wonderful, in the constellation of the Whale, or Cetus, which is designated by the fifteenth letter of the Greek alphabet, omicron, thus: O Ceti.

The Greek letter method of naming the stars has, then, its conveniences. But, after all, when a star, like anything else, comes to have any special individuality for us we

desire a name for it that is all its own. When we come really to know splendid Arcturus, we do not care to call him Alpha Boötis any more than we want to call a dainty spring beauty *Claytonia Virginica*, or the golden-eyed white daisy *Chrysanthemum Leucanthemum*. And, happily, we are not often put to this discomfort, for there is no star of the first magnitude in the northern hemisphere that has not an individual name. In the southern hemisphere, however, there are three; Alpha Centauri, Beta Centauri, and Alpha Crucis. Alpha Centauri, we have seen, is the star that is nearest to us. If it had been known to the ancients in the unscientific days when one cared more to know than to classify and had time to consider the individual, no doubt we should have had a picturesque name for our nearest neighbor. I remember feeling distinctly grateful to the old astronomers for having given individual names to much less conspicuous or important stars. A window in my bedroom opens out towards the northeast, and during the autumn and early winter the Dipper is visible there a good part of the night. Many times it has happened that I have suddenly opened my eyes in the night and found there

beaming down upon me the soft rays from the star Mizar, which lies just in the bend of the handle of the Dipper and next to the end star, and its tiny companion Alcor, that seems to send its own little beams almost along the same path. The simple friendliness that I felt in encountering them in this way came as much, I think, from my being able to greet them by their own names as from their intrinsic beauty and steadfast cheerfulness.

XVIII

THE LIGHT OF THE STARS

STARS are classified according to their brilliancy into magnitudes; and as applied to them, the word magnitude has a specific meaning. It has reference solely to their brightness and has nothing to do with their proportions. Many stars which appear to us very small and faint we know to be of immense size, far exceeding some of the most resplendent stars of the heavens; so there is no relation between the real and apparent magnitude of a star—that is, between its size and its brilliancy.

This use of the word magnitude was fixed in astronomy in the early days of the science, before the telescope had been invented and before there was any way of judging of the dimensions of a star other than by its appearance to the naked eye. The stars that seemed the largest and brightest were sup-

posed really to be so, and were said to be of the first magnitude; the next brightest were called second magnitude stars, the next third magnitude, and so on. All the stars visible to the naked eye were divided according to their lucidity into six magnitudes, and modern astronomers have found it convenient to continue this way of describing their comparative luminous power, and have applied the same principle in describing telescopic stars down to the twentieth magnitude, which is said to be the faintest that can be seen in even the largest telescopes.

It is, of course, an arbitrary classification, for there are stars of every degree of brightness between Sirius, the brightest star in the heavens, and the faintest star we can see; and, so far as accuracy is concerned, we might as well have sixty magnitudes among the visible stars as six. Moreover, with no more accurate measurement than one can make with his eye, it is not easy for the ordinary observer to tell the difference between the amount of light we receive from a faint star of one magnitude and a bright one of the next lower magnitude. Since naked-eye observation was the only way of determining stellar magnitudes among the ancient astronomers,

there was considerable difference of opinion concerning the brightness of such stars as were on the border lines of each magnitude. To the first magnitude there were assigned anywhere from fourteen to twenty stars, and in the lower magnitudes the difficulty of agreement was even greater.

Modern astronomers, while retaining the old method of classification, have endeavored to systematize it by the accurate measurement of the amount of light we receive from each star. This is done with an instrument known as a photometer, by means of which very slight gradations in the light of the stars can be determined. With this instrument practically all the naked-eye stars have been measured, and they have been catalogued accordingly. This work has been done in this country under the direction of Prof. E. C. Pickering, of the Harvard Observatory, with a photometer of his own invention. At Oxford, England, the late Prof. Charles S. Pritchard carried on the same work, using a different sort of photometer. The photometric measurements made at Harvard and at Oxford show practically the same results, the slight difference being attributable probably to the difference in atmosphere.

In making the measurements some standard of light is taken, and the light of each star is compared with it and the magnitude determined according to a ratio which has been agreed upon. In the Harvard Photometry, the Pole Star (Polaris) is the standard star taken for comparison. It is a conspicuous and important star that every one knows, and has long been rated as of the second magnitude — even in the days of rough judging of the brightness of the stars.

One would think that in determining magnitudes, the brightest star, or one of the brightest, would be taken as the standard, and all the others would be graded from that. This is probably what would have been done if the stars had not been classified as to brightness until the delicate instruments for measuring their light were invented. As it is, the classification was made many hundred years ago, and though modern astronomers are endeavoring to express the comparative gradations of light as accurately as possible, they still do not much disturb the distinctions which have been long familiar.

By photometric measurements the gradations of light between the different magni-

tudes are expressed in tenths by decimal fractions. Thus the magnitude of one star is 2, that of another a little less bright is 2.1, and so on to 2.9, which is almost as faint as that of a star whose magnitude is 3. The larger the fraction the nearer the magnitude of the star is to the next magnitude below the one in which it is classed, and the higher the number of the magnitude the fainter the light of the star.

For the ordinary observer it is sufficient to know that a star is of the first, second, third, or whatever magnitude, as the case may be. These nice distinctions in tenths between degrees of brightness are useful more to the close student than to the general reader. The usual way of classifying is to designate a star as of the magnitude to which it is nearest. Consequently each magnitude reaches out on each side and takes in all stars that are not more than five-tenths of a magnitude from it. For example, all are called first magnitude stars whose magnitude is brighter than 1.5. If a star's brilliancy is found to be 1.6, it is classed as a second magnitude star, and all are of the second magnitude from this down to 2.5; and similarly the other magnitudes are reckoned.

This is true of all the magnitudes except the first. This has its limit only on one side. It includes all stars that are brighter than 1.5 magnitude. There are but twenty stars of the first magnitude, but the individual lustre of them varies so as to cover nearly three magnitudes. This difficulty is overcome by expressing the magnitude brighter than 1 as 0, the magnitude next brighter as −0, and the next as −1. The magnitude of Sirius, the most brilliant of all the stars, is −1.58. Altair and Aldebaran, in the northern hemisphere, and Alpha Crucis, in the southern, are almost exactly first magnitude stars. Seven others are less bright than Aldebaran, and eleven are between Aldebaran and Sirius.

According to the Harvard measurements the magnitudes of the twenty brightest stars are as follows:

Sirius (Alpha Canis Majoris)	−1.58
Canopus (Alpha Carinæ)	−0.86
Alpha Centauri	0.06
Vega (Alpha Lyræ)	0.14
Capella (Alpha Aurigæ)	0.21
Arcturus (Alpha Boötis)	0.24
Rigel (Beta Orionis)	0.34
Procyon (Alpha Canis Minoris)	0.48
Achernar (Alpha Eridani)	0.60

Beta Centauri	0.86
Altair (Alpha Aquilæ)	0.89
Betelgeuse (Alpha Orionis)	1.00 max. 1.4 min.
Alpha Crucis	1.05
Aldebaran (Alpha Tauri)	1.06
Pollux (Beta Geminorum)	1.21
Spica (Alpha Virginis)	1.21
Antares (Alpha Scorpii)	1.22
Fomalhaut (Alpha Piscis Australis)	1.29
Deneb (Alpha Cygni)	1.33
Regulus (Alpha Leonis)	1.34

The light ratio agreed upon between the different magnitudes is 2.5. That is, a standard star of each magnitude is two and a half times brighter than a standard star of the next lower magnitude. Or, to put it the other way, each magnitude is four-tenths as bright as the next higher magnitude. This makes a first magnitude star one hundred times brighter than a sixth magnitude star, and a sixth magnitude star ten thousand times brighter than one of the sixteenth magnitude. In the same ratio, a first magnitude star would be nearly four hundred thousand times brighter than a fifteenth magnitude, and thirty-seven million times brighter than a twentieth magnitude. This would make Sirius something over two hundred million

times brighter than the faintest star of the twentieth magnitude.

But notwithstanding this vast superiority in brilliancy of the brightest stars, we get more starlight from the faint stars as a whole than from the bright ones as a whole. This is on account of the number of the faint stars; for it has been found that each magnitude is about three times more numerous than the one which precedes it. Hence, though a first magnitude star is two and a half times brighter than a second magnitude star, there are three times as many second magnitude stars, and consequently we get more light from them as a whole. Though a first magnitude star is three thousand times brighter than a tenth magnitude, yet there are seventeen thousand times as many of the tenth magnitude as of the first. This progressive increase in number is an approximate estimate, but it is deduced from actual catalogues of the stars and is fairly accurate.

According to this ratio of progression, and making due allowance for the way in which one magnitude merges into another, the six or seven thousand stars visible to the naked eye are distributed about as follows:

20	stars	of	the	first	magnitude,
60	"	"	"	second	"
180	"	"	"	third	"
540	"	"	"	fourth	"
1620	"	"	"	fifth	"
4860	"	"	"	sixth	"

Making 7280 the total number of stars visible to the naked eye. How many stars one really sees of this seven thousand depends upon the state of the atmosphere and the keenness of one's sight. Most persons under ordinary conditions fail to see nearly two thousand of them, and it is an eye of remarkable power that sees them all. However many one sees, there are always many more just on the verge of visibility that seem to come and go. This is one reason why there seem to be so many more stars in view than there really are.

It is to be remembered that all this applies only to the stars as we see them, and has no relation to their real size or their light-giving power. They may be brighter because they are nearer to us, or because they are really more brilliant and give out more light than others; but none of these qualities is determined by their apparent lustre. As a

matter of fact, some of the brightest stars are very well known to be not the largest. There is reason to think, however, that in general the brightest stars are probably the nearest to us, though there are many exceptions, and though several of the stars known to be among those nearest to us are of the sixth and seventh magnitudes.

XX

THE DISTANCES OF THE STARS

SEVENTY years ago we did not know the distance of a single star. Though astronomers had been working on this problem for many years, it was not until 1838 that they succeeded in getting what seemed to be any fairly accurate measurements. In this year the distance of 61 Cygni was calculated with reasonable correctness; and at about the same time it was discovered that Alpha Centauri was within calculable distance and was even nearer than 61 Cygni. Strangely enough, these two stars have proved to be among our nearest neighbors. No star has been found since that is as near as Alpha Centauri, and for many years 61 Cygni was supposed to be the next nearest. Recently, however, another small star, with no individual name, but appearing in the catalogue as 21,185 Lalande,

has been found to be a little nearer than 61 Cygni.

The distances of a number of stars have been calculated since 1839; and through their knowledge of the distances of these, astronomers have been able to at least place limitations on the distances of others, and taking color, brightness, and other characteristics into consideration, have made inferences also as to size and constitution which it seems reasonable to believe are very near the truth. The ascertainment of distances has opened up a very large field of investigation; for, until the distance of a star is known, we can know but little of its size or light-giving power, and hence little of its real nature, though its chemical constitution may be revealed by the spectroscope. Two stars may be apparently of equal size and brilliancy, but when we learn that one is many times farther from us than the other, we realize how much greater the more distant one must be. Take, for instance, the two brightest stars, Sirius and Canopus. They are both so much brighter than a standard first magnitude star that they are really in a class by themselves, though called first magnitude stars. Sirius is the brighter

of the two, and it is five hundred thousand times farther from us than the sun. But Canopus is so far away that its distance has never been ascertained with certainty. Many attempts have been made to measure it, but the only result reached is that it probably cannot be nearer than twenty million times the distance of the sun. Since the sun is ninety-three millions of miles from us, this would make Canopus more than a quadrillion of miles farther away than Sirius; hence it must be very much the larger body of the two.

Measuring the distance of a star is called by astronomers finding its parallax. Roughly speaking, parallax is the apparent change of position that an object seems to make when viewed from different points. If you hold a pencil out in front of you about one foot and look at it with first one eye and then the other, you will see that it seems to change its position relative to any object back of it. If you hold the pencil farther away, you will see that the change of position seems less, and if you place it still farther away, there seems to be no change of position at all. Then if you will move your head from side to side and thus lengthen the line between the two points of observation, which was at first only

the distance between your eyes, the pencil will have to be placed still farther away before it seems to remain stationary when looked at from both points of view. The longer the distance between the two points of observation, the farther away the object observed will have to be to remain in apparently the same place when viewed from each point. When mathematicians know the length of the base line (that is, the line connecting the two points of observation), and can measure the angle made by the meeting of the other two lines (that is, the lines from the two points of observation to the object observed), they can tell how far away the object is.

When looked at in the ordinary way, a star never seems to change its position in the heavens. Even if viewed from points whose distance from each other is the whole diameter of the earth, eight thousand miles, it shows no change of position.

At first thought one would think that we could not find a line longer than that from one side of the earth to the other. But astronomers have found one in space. It is the diameter of the earth's orbit, or the path over which the earth travels in its yearly

journey around the sun. This diameter is 186,000,000 miles long, or more than twenty-three thousand times as long as the diameter of the earth. Observations of the stars whose distance is to be measured are made when we are at one point in the earth's orbit, and then again six months later, when we are at the opposite point, or 186,000,000 miles removed from the first. A few stars change their apparent positions when thus observed from the two ends of this great line; but the changes are still very slight. By strict mathematical calculation we know, however, that any star that shows a change of position of only one second, the smallest subdivision of a circle, when viewed from each end of a line 186,000,000 miles long, must be a little more than nineteen trillions of miles from us. Thus far no star in the heavens has been found to change its position this much; or, as astronomers say, no star has yielded a parallax of one second (1″). Consequently, as far as we know, there is no star as near to us as nineteen trillions of miles. The largest parallax that has been found is .75 of a second.

The sun is ninety-three millions of miles from us, yet if we were journeying in space,

we might reach the sun and then go two hundred thousand times farther away and still not come near any fixed star. Indeed, we should have to go still eighty thousand times the sun's distance from the earth, for a parallax of .75 of a second means a distance of seven trillions of miles more than the nineteen trillions. In other words, the nearest star that has been discovered is about twenty-six trillions of miles away, which is equal to two hundred and eighty thousand times the distance of the earth from the sun.

Other stars are many times farther away than this. Their distances in miles expressed in figures are not much easier to comprehend than infinity. Most astronomical numbers are too large to comprehend and too cumbersome for easy use. For this reason the distance of the earth from the sun (93,000,000 miles) has been adopted as the astronomical unit, and in expressing long distances we ordinarily say so many times the sun's distance. But some of the stars are millions of times the sun's distance, which still gives us an awkward lot of figures to deal with. Astronomers have, therefore, chosen another unit of length for expressing stellar distances. This unit is the distance over which

light passes in a year. We know that light travels at the rate of 186,400 miles in a second. This equals about six trillions of miles in a year, or about sixty-three thousand times the sun's distance. Therefore, for every six trillions of miles that a star is distant we speak of it as one year away. The nearest star, then, is a little more than four and one-third years away, which means that its distance is more than four and one-third times six trillions of miles.

We do not see the light from the nearest fixed star for more than four years after it leaves the star. From many stars we do not see it for a hundred years, or for many hundreds of years. From some of the faintest stars it may take light even thousands of years to reach us. No doubt streams of light are travelling towards us now which set out on their long journey before Christ was born and have not yet reached us. The stars from which they come may no longer exist, but we shall never know it. The Pole Star, which we think is the most stable thing in the universe, might be extinguished for nearly half a century and we should still be ignorant of the fact; for the light that we now see probably started on its journey to

us almost fifty years ago. And this though the velocity of light is so great as to send it around the entire circumference of the earth (25,000 miles) more than seven times in a second. From the nearest fixed star our sun, which gives us ninety billion times more light than a first magnitude star, would shine only as a star of the second magnitude. Neptune, the farthermost planet of the solar system, is almost three billions of miles from the sun; yet between us and the nearest fixed star we could have several thousand such solar systems and still have some room left.

We think sound travels fast when we say that it goes at the rate of one thousand and ninety feet per second. But if it were possible for sound to travel to us from the nearest fixed star, it would, even at this rate of speed, spend three millions of years on the journey through space. Fortunately sound is dependent on our atmosphere for its motion and does not travel through space as light does. If it did, we would probably have such a mighty and continuous thunder that our ears would have to be constructed very differently from what they are now to stand the shock; for tremendous explosions

and upheavals are going on all the time among the stars, of which our sun is one.

There are about seventy-two stars for which a parallax has been found, and for about fifty of them with, it is believed, pretty nearly exactness. Many more have seemed to yield a parallax; but the possibility of error in delicate calculations and observations is so great that astronomers, who are a very conservative set of men, have not in these cases accepted the results as final. Slight corrections are being made all the time, even in the case of parallaxes that had seemed correct. In such observations allowance must be made for errors of various kinds. Even personal peculiarities must be taken into account; for, with the same honesty of purpose and working with the same instruments, persons of different temperaments will still see things a little differently. So in the final allowance for probable error which follows any calculation of delicate problems in astronomy, the astronomer takes his personal equation into consideration. But apart from this element of uncertainty, it is still not all a plain case of making and recording observations in seeking a parallax. Account must be taken of refraction, which

causes an apparent deviation from the real position of an object; of the motion of the earth through space, which does not stop for the making of any observations, however important; of nutation, which is a wabbling of the earth on its axis; of precession, which is another motion of the earth; and of still other motions which are disturbing.

The work of measuring the distances of the stars is being pursued with great diligence and ardor. Every clear night the search is going on, and the number of parallaxes found is increasing. A special effort is making to resolve into some sort of order the apparently haphazard distribution of the stars in the heavens, and find out if there is any one class of stars that is nearer to us than another, and definitely what connection there is between distance and apparent lustre. To this end great effort is being made to secure even approximately correct parallaxes for a large number of stars in cases where absolutely correct ones have not yet been found.

There seems to be some reason to believe, though astronomers do not state it dogmatically, that on the whole the brightest stars are nearest to us. But there are so many exceptions that perhaps it would be

more accurate to say that the faintest stars are farthest away. Alpha Centauri, the nearest star of all, is a brilliant first magnitude star. Procyon, another first magnitude star, is something less than ten light years away. Sirius, the brightest star in the heavens, is also comparatively near, its light journey through space being a little more than eight years (8.8). On the other hand, 61 Cygni, which is of the fifth magnitude, is more than half a year nearer than Sirius; and the small star of the sixth magnitude known as Lalande 21,185 is more than a year and a half nearer; while Canopus, the star next brightest to Sirius, takes not less than three hundred and twenty-five years to send its light to us. Arcturus, one of the brightest stars in the northern hemisphere, is more than a hundred years away; Betelgeuse, Antares, and Regulus are each at least one hundred and sixty-two years away; and Spica and Rigel have not yet yielded any parallax. Of the other first magnitude stars some have been measured and some have not. Of those that have been, not one is nearer than fourteen years and only two are nearer than thirty years. So, while it may be true of the stars taken in large numbers that a

larger proportion of the bright ones are near us than of the faint ones, it does not necessarily follow that because a star is brighter than others it is, therefore, nearer, nor that any particular faint star is among those that are farthest away. Brightness is one of the criteria of nearness, but it is not always the determining one.

Of the distances of the stars from each other we can have no conception until we know their distance from us. Some of those that appear to lie very close together may only lie in nearly the same line of sight and may really be separated from each other by many times their distance from us. There is reason to think, though, that many of the groups are not mere accidents of vision, but that most of the stars composing them have some close connection and are probably comparatively near each other. This is indicated sometimes through spectrum analysis and sometimes through telescopic observation. By the spectrum we learn that the stars in certain groups are all in nearly the same stage of development; and thus they seem to have had a common origin and may be comparatively near each other. This is the case with the stars of the Pleiades. By

the telescope we learn that all the stars in certain groups are moving through space in the same direction; and thus they seem to have a common destination. This is the case of five of the principal stars forming the Dipper. Sometimes it is found that the stars in a group revolve about each other, thus forming a little system of their own; and by the rapidity of their revolutions we can get some idea of their nearness to each other.

It seems a little strange that the stars can thus disport themselves in space so that we can see it by the right sort of looking, and yet in most cases can keep from us so securely the secret of their distance. Some day they will show us a way to this secret, and when we have once learned it many other secret doors will be unlocked. For in astronomy every discovery that is made is a direct aid towards making others. Already a vague connection has been established between distance and two other characteristics of the stars: independent motion through space and motion around each other; for, besides brightness, which I have spoken of, the other two criteria of nearness are large proper, or independent, motion and a quickly revolving

companion. Yet 1830 Groombridge, which has the largest independent motion of any star yet observed in the northern hemisphere, is not one of the nearest stars, but is ten times as far away as Alpha Centauri; and for Algol, which has a quickly revolving companion, no parallax has ever been found; while Sirius and Procyon, both comparatively near by, have companions with a period of nearly fifty years.

XX

DOUBLE STARS

A GREAT many of the stars that we see as one with the naked eye are, in reality, composed of two, sometimes of three, and in a few cases of four or more stars. The reason that we see them as a single star is, either that they are too close together to show any space between them at the enormous distance they are from us, or that one of them is too faint to be visible without a telescope. Castor is an example of the first case. The two principal stars composing it are of the second and third magnitudes, and either of them could be seen with the unaided eye if they were not so near together. Their nearness, of course, is only comparative. Hundreds of millions of miles probably divide them; but their distance from us is so great as to make many hundreds of millions of miles dwindle to a mere point. Regulus

is an example of the second case. It has a companion star which is too small to be seen with the naked eye, and yet the distance between the two stars is no less than that between some other stars which the eye can easily separate because they can both be seen by the eye alone.

Sometimes we loosely call a star double when we can really see without a glass the two stars composing it. Epsilon Lyræ, which we already know, is such a star. To many persons it seems to be a single star; but a good eye will discover that it is two. They are three minutes apart, and this is about the smallest distance that the eye can discern among the stars.

The star next to Aldebaran in the V-shaped figure of which it is a part is also spoken of as a double star, though its two components are as much as six minutes apart and can ordinarily be seen with the unaided eye. There are many such double stars. But astronomers do not call a star double unless a telescope is required to separate the components of it, and even then they reject all stars that do not lie nearly ten times nearer together than the two principal stars of Epsilon Lyræ.

Sometimes two stars lie in such a position that they seem to us to be almost touching each other, yet are in no way connected and only happen to lie in the same line of vision, one being enormously farther away than the other. Their appearance as one is a mere matter of perspective. Such combinations of the light of two stars are called optical doubles, and are of no special importance as double stars in astronomical investigations after it has been fully established that they have no physical connection.

True double stars do not lie near each other by mere chance. They are held together by physical bonds which keep them forever revolving around each other, and their revolutions are what betray to us the relationship of the stars taking part in it. Sometimes it requires many years to determine whether there is a physical connection or not. For even though stars may be moving at the rate of many miles a second, their distance from us is so great that it takes a very long time for us to discover any motion at all. Hence, a star that requires several hundred years to complete its journey in its orbit would hardly reveal any perceptible motion in the lifetime of one man. A convenience

it would indeed be to the modern astronomer if he could command the same consideration as the old historian Berosus says was given to the antediluvians when God prolonged their days to five or six hundred years in order to give them time to complete astronomical observations. The brevity of life, however, does not stay the inquiring mind. The work of investigation is passed on from hand to hand with almost as much continuity as if it were pursued by a single man.

Generally speaking, there is a real connection between two stars when they remain in the same relation to each other during a long series of years. For each star is in motion and has its own, or what we call its "proper," motion in the sky. If its companion has the same motion, and the two stars thus keep together, there is reason to suppose that they form part of the same system. If they remain together and yet change their relative positions, we know that they are circling round each other and are undoubtedly of one system. But sometimes in their revolutions through their incredibly large orbits the two stars are enormously farther apart at one point than at another

and may seem to be receding from each other. In such cases it requires long years of observation to determine whether each is going its own way and they will continue to recede, or whether they are bound together by gravitation and will in time approach each other again.

Sirius and its companion are entirely inseparable at one point in their circuit and at another can be separated by a good telescope. But as their period of revolution is only about fifty years, their relation was soon established after the smaller star was once seen during one of its periods of greatest distance from the principal component of the system.

Castor and its more distant companion, on the other hand, can always be seen separately by the aid of the telescope. But it was only after they had been known as a double star for more than a hundred years that any physical association was suspected between them. It came about then by the accidental discovery that while once the prolongation of the line joining Castor and Pollux would run through Castor's companion, it was no longer so; but that the companion had moved quite out of line with Castor and Pollux, showing that the two

stars must be in revolution. Their period of revolution was once supposed to be about four or five hundred years, but it is now supposed to be somewhat longer—probably about a thousand years. This change of opinion as to the length of Castor's period is due to the fact that when the system was first discovered the two stars were nearer together than they now are and were, consequently, moving more rapidly in their orbit. Being farther apart now, they exert less influence on each other and move more slowly. This lessens their mean rate of speed and thus lengthens our estimate of their period of revolution.

Double stars that are not mere optical doubles, but are proved to have some physical connection, and, hence, to revolve around some common centre, are known as binary stars, or binary systems, and the stars composing such a double star are spoken of as its components. Those that can be separated with the telescope are called visual, or sometimes telescopic, binaries. But there is a class of binaries that cannot be separated even with the strongest telescope. Their double nature is made known to us by means of the spectroscope, and they are

called spectroscopic binaries. Their discovery is one of the most interesting results of the use of the spectroscope in astronomy.

By the displacement of certain lines in the spectrum of a star astronomers are able to determine the swiftness and direction of its motion. In the case of a double star the components revolve around each other, alternately approaching and receding from us. The lines of their spectra indicate these motions and betray the fact that they are circling around in an orbit, and are, hence, double stars, since if they are revolving they must be revolving around something. When the two stars are of the same class spectroscopically, they will each have the same kind of spectrum and the lines of their spectra will alternately appear double and single, according as the stars are side by side to our view or in the same line of sight from us. When the two stars composing the binary are so different in their stage of development that one is nearly dark, the lines of the spectrum of the bright component will simply oscillate back and forth, for, of course, a star that does not radiate light has no spectrum. Mizar is an example of the first class and was the first star to be identified as of that class, this oc-

curring so recently as 1889. Mizar was also the first star discovered to be a double star. Spica is an example of the second class, since its companion star is almost non-luminous and shows itself only by the wavering lines of Spica's spectrum. Capella is of a class between the two, where the spectra of both components can be seen, though they may be slightly different through one star being in a more advanced stage of evolution than the other.

Up to the middle of the seventeenth century such a thing as a double star was unknown. In 1610 Galileo first used his telescope, by which he discovered the moons of Jupiter. For forty years after that the heavens were scanned with various telescopes more or less rude in construction, but not once did it occur that a star which looked single to the naked eye became known to be double as viewed through a telescope. Finally, in 1650, Mizar was discovered to be composed of two stars. The idea once entertained, double stars became an object of special quest, and many others were discovered in quick succession, among them Alpha Centauri and the famous Theta Orionis, the star in the nebula in the sword of Orion, which was discovered

as early as 1689 to be not only double, but quadruple. But no one dreamed that double stars were anything more than optical doubles. It was supposed that by mere chance they both lay in the same line of vision from us, against the same background of black space, but one of them necessarily much farther away than the other.

More than a hundred years after the first double star was discovered, and so recently as about the time of our Revolutionary War, a systematic search for double stars was begun. In less than two years thirty-three stars were added to the number already known. The astronomer Herschel then set about making a special study of double stars, in the hope that he might be able to learn something about their distance. The idea that one was far behind the other in our line of sight at least differentiated them as to distance and suggested the thought that it might be possible to discover some shifting of the nearer star in its relation to the farther one. The unexpected happened again, and a new scientific truth was discovered almost, as it seemed, by accident. The stars were revolving around each other! Another of nature's secret doors had been burst open by

the continuous pressure upon it of zealous, untiring workers while chiselling away one fastening after another.

By 1802 it was proved beyond a doubt that many of the so-called double stars were truly double—twin suns swinging around a common centre of gravity: millions of miles apart, no doubt; but held by that mysterious force that keeps our own system together, in bonds that can never be loosened.

Here was a field for endless work among astronomers, and the wildest fancy could scarcely predict too much from it in the way of results. Here was proof, and our only proof, that Newton's law of gravitation is universal and not peculiar to the solar system. It holds the great stars in their courses as certainly as it binds our little planet and its satellite. Here was certain information that there were many other systems like ours in the universe: a vast central orb holding smaller ones by invisible chains and swinging them around it as a boy sometimes swings a pot of burning coals suspended on a string.

Sometimes two fiery suns of almost equal size are circling around each other. They may each be the centre of a planetary system and so far apart that they show as

mere stars to each other. That they are so far apart, we know in some cases; and we even know that in some cases dark bodies are revolving around them. Why may it not be that many others are thus far apart and accompanied by dark bodies which we have as yet no means of discovering? And why may it not be that our sun has a far distant companion that holds it in a vast orbit over which it is travelling in its mysterious flight through space, which we know it is making but know not why? There is no calculating on what a wave of progress in astronomical learning the discovery of binary systems among the stars has launched us.

As soon as the fact that there was a physical connection between the components of some of the double stars was established, many workers began to devote themselves to the observation of such stars, sorting out and discarding the mere optical doubles, watching and recording the movements of those which proved to be real binary systems, and discovering new ones all the time. For nearly ninety years the work was carried on by means of the telescope, and more and more pairs came into view as larger and larger telescopes came into use. It was then found

that more than one-twentieth of all the stars as bright as the eighth magnitude were double stars as seen in the large telescopes. They were not, of course, all true binary systems, but many of them were. Then, just eleven years before the nineteenth century closed, came the discovery that binaries which even the strongest telescope would fail to separate could make themselves known through the spectroscope in the manner already described, and the field of discovery and investigation was still further enlarged.

Many thousand binary systems are now known to exist. About one hundred and fifty of these are spectroscopic binaries, and new pairs are being rapidly, almost daily, revealed. From the proportion of binaries in a given number of stars examined, it has been estimated that one out of every five or six stars is probably a system of stars, and it may yet develop that no star is thrown out into cold space entirely alone. If they are not twin suns shining by their own light, it is probable each one is at least attended by some dark body, or planet, like the ones circling about our sun. Such systems as ours is now supposed to be, however, are in the minority, most of the binary stars

thus far discovered being either double suns or having a dark companion of such size as to eclipse them more or less in some part of their orbit.

Nearly a hundred of the binary systems discovered have proved to be multiple systems composed of anywhere from three to seven stars. Polaris is a triple star, Mizar a quadruple, Theta Orionis divides into six bright stars, and Epsilon Lyræ is composed of seven. From the frequency with which this happens, it is hardly surprising to find almost any binary resolve itself on further observation into a system of several stars. Many binaries that can be seen with a telescope have been shown by the spectroscope to have both components double, thus making a quadruple system; and at least one star (Beta Aurigæ) has made itself known as a quaternary system by means of the spectroscope alone.

The orbits of more than fifty systems have been computed, showing periods of revolution from less than two days to more than a thousand years in length. The far-distant visual couples swing slowly and majestically around their common centre, while the close companions whirl with almost unthinkable

rapidity through their allotted orbits, for the shorter the distance between two stars the greater gravitational force they exert upon each other and the more swiftly they compel each other to rotate.

The fastest revolving couples are, of course, spectroscopic binaries, many of which are so close together as to be all but in contact. In proportion to the number of each, the orbits of more spectroscopic binaries have been determined than of the visual systems; for telescopic doubles must be observed until it is shown that they either are or are not in revolution, while spectroscopic systems are discovered *because* they are in revolution.

The shortest period known for a spectroscopic binary is almost seven hours, and until recently the shortest period found for a visual binary was eleven years. But a fourth magnitude star about half-way between Altair and the square of Pegasus, which the telescope shows to be double, is now supposed to have a period of only five years — the shortest yet discovered for a visual binary.

It is interesting to know that the longest period found that has reasonable claims to accuracy is that of another fourth magni-

tude star in the same region of the heavens. It is estimated to be nearly sixteen hundred years; but it will require several hundred years of observation to fully verify this estimate. The longest period that has been computed and fully authenticated is about four hundred years, though much longer periods are known to be approximately correct.

The discovery of binaries, or systems, of stars has a most important influence in the progress of astronomy. In establishing the universality of the law of gravitation it opens the way to knowledge of various sorts which would otherwise be unobtainable. When the distance of a pair of stars is known and the time that they require to revolve about each other, we secure data for determining the size of their orbit, their mass, their real light-giving power, and their rate of speed. In addition to this, if we learn from the spectroscope the chemical composition of the stars, it would seem as if their whole story was nearly within our grasp.

XXI

THE CONSTELLATIONS

THERE is a general impression that knowing the stars means knowing the constellations; and with this idea in their minds it is no wonder that many persons grow discouraged at the very outset in their endeavors to make some acquaintance with the stars. In themselves, in fact, and as a whole, the constellations are not as interesting as the individual stars. Most of them do not much resemble the thing for which they are named, and hence are mere abstractions bounded by certain imaginary and by no means definite lines. Many of them overlap each other. The tip of one of the horns of Taurus is in Auriga; Andromeda and Pegasus depend upon the same star to complete their outline; and in some other cases a star is assigned to two constellations, or families, so that it is difficult to tell of which one it is the step-child.

To enjoy the constellations one must be satisfied not to expect too much of them. The splendid ones that mark a certain section of the skies to us, as well as the small and beautiful ones that remind us by their presence that a certain season has arrived, yield their fullest pleasure when we take them as we do our human friends—for what they give us, without any severe exactions as to consistency or any desire to make them fit a preconceived model. The tracing of the various figures represented by the constellations was not the working out of an exact science, but it was an æsthetic occupation, and the imagination must be used to see, as the ancient star-gazers did, the heroes, kings, and queens, and birds and dragons fixed on the purple walls of the sky.

It is not necessary that one should be able to trace all the constellations in order to have a friendly and familiar acquaintance with all the important naked-eye stars. Still one can hardly be said to know the aspect of the heavens until he knows the principal constellations—the ones that took shape in the minds of the shepherds, sailors, and other out-door people in the days when imagination fashioned them and scientific

order was of less import than it is to-day. These early forms include the twelve constellations of the zodiac, for instance, which mark the path of the sun and the moon and the planets across the heavens; the conspicuously beautiful constellations, like Orion, Lyra, Leo, Scorpius, and others; and the familiar ones forever circling around the north pole, and always visible to us, like Draco, Cassiopeia, and the two bears.

Moreover, however indifferent one may be to the science of astronomy, an intelligent person can hardly fail to feel a little uncomfortable when he has so large a body of natural beauty hanging over him in full view half of his life and yet has no familiarity with it. It was some feeling of this kind, no doubt, that led Thomas Carlyle to cry, "Why did not somebody teach me the constellations and make me at home in the starry heavens, which are always overhead, and which I don't half know to this day?"

Of the ancient constellations there are about forty-eight. They are all outlined by stars that can be seen with the naked eye and are as open to our vision as the clouds, the trees, and the hills. In them are contained all the brightest stars, and there is no

conspicuous part of the heavens that is not covered by them. Once we are familiar with them, the whole sky becomes glorified to us beyond Achilles' shield, which Hephaistos fashioned and wrought thereon "the heavens, and the sea, and the unwearying sun, and the moon waxing to the full, and the signs every one wherewith the heavens are crowned, Pleiades, Hyades, and Orion's might, and the Bear that men also call the Wain, her that turneth in her place and watcheth Orion, and alone hath no part in the baths of Ocean."

There are also about thirty other constellations, of modern origin and more or less recognized by astronomers. Most of them are among the southern stars and are too far south to come within our view; for the old astronomers were so situated geographically that they were not familiar with the skies of the far south. The other modern constellations are not of much interest or importance, being in the main composed of a few inconspicuous stars occupying stray spots in the sky not covered by the original constellations, and as often as not named for mathematical instruments, without even the compensating advantage of resembling

any more than the older constellations do the objects for which they were named.

Fourteen of the principal constellations have already been described more or less fully in introducing the first magnitude stars. With these as connecting links it will be easy to trace the others.

XXII

THE LITTLE BEAR AND POLARIS

THERE are six well-defined constellations that are always above the horizon in our latitude. We can see them on any clear night from sundown to dawn. They are all in the north and revolve slowly in a small circle around the north pole once every twenty-four hours. In one sense the most important of these six constellations is Ursa Minor, or the Little Bear. The reason of its importance is that the north pole lies within its boundaries.

The north pole is nothing more than the point where the imaginary polar axis of the earth would touch the sky if it were extended that far. But since the earth revolves on its axis, the entire heavens seem to us to revolve around its extension; so the north pole is to our view the centre of the universe and the most important point in the skies.

THE CONSTELLATIONS AROUND THE POLE

THE LITTLE BEAR AND POLARIS

Of all the stars that can be seen by the naked eye the one nearest to the north pole is Polaris, or Alpha Ursæ Minoris. It is called the Pole Star, or the North Star, and is ordinarily regarded as marking the exact point of the north pole. It is, in truth, a degree and a quarter from the polar point and revolves around it each twenty-four hours in a little circle two and a half degrees in diameter. A diameter of two and a half degrees is nearly five times the apparent diameter of the moon, which is only a little more than half a degree. But the moon, by reason of its brilliancy, seems to cover more space on the sky than it really does, so we must make allowance for that fact in such a comparison.

If one has a desire to find the exact location of the pole, it may be done by drawing a line from Polaris to Mizar, the middle star in the handle of the Great Dipper. Mizar is on the other side of the pole from Polaris and almost exactly opposite; and the line will pass through the pole, which lies one and a quarter degrees from Polaris.

Within the little circle that Polaris makes around the pole are many stars that are not visible to the naked eye. As many as eighty

have been seen through the telescope, while as many as two hundred have been seen on the photographic plates. The star nearest the pole is a small telescopic star of the ninth magnitude. It is only two minutes, or one-thirtieth of a degree, from the exact polar point.

Owing to what is known as the precession of the equinoxes, the pole does not always point to the same spot in the sky. It describes a little circle of its own once in every twenty-five thousand years, and as it journeys it confers the distinction of being the Pole Star upon several different stars. In about two hundred years from now it will approach our present North Star, Polaris, to within a little less than half a degree. The circle which Polaris will then make around the pole will have a diameter of about fifty-three minutes, which is still something larger than the diameter of the moon. After that, the pole will begin to move away from Polaris, and in something less than twelve thousand years will be within five degrees of the beautiful Vega, and she will be our Pole Star for the next three thousand years. Then the pole will slowly recede from Vega, and in another twelve thousand years

Polaris will again become the Pole Star. So, in spite of all these changes, each generation during these thousands of years will have its Pole Star in whose "true-fixed and resting quality" it can rely as absolutely as we now do on Polaris. For the change takes place so gradually that a single generation is not conscious of it.

Polaris is not only the centre of all the stellar company, but also of a little circling system of its own. It has a companion of about the ninth magnitude, and has also two almost dark companions revolving around it, which were discovered by means of the spectroscope. It is, therefore, a telescopic double, and the brightest component of the double star is a spectroscopic triple. So the star we see as one is really four. It is so far distant that its light does not reach us for nearly forty-five years. If it were suddenly blotted out of existence a whole generation of men might guide their ships by its light after the star itself had gone.

Polaris is the brightest star in the constellation of Ursa Minor, or the Little Bear. Its Greek letter name is Alpha Ursæ Minoris. It was also called in former times Cynosura, meaning the end of the dog's tail. It is at

the end of the tail of the Little Bear: and there is some reason to think that the Little Bear was once thought to be a dog instead

THE LITTLE DIPPER

of a bear. Our word "cynosure" gets its meaning from Polaris, which is the centre of attraction in the heavens.

THE LITTLE BEAR AND POLARIS

In the Little Bear, as in the Great Bear, the distinctive feature of the constellation is the Dipper. It is formed of seven stars and somewhat resembles the Great Dipper: but its handle is curved towards, rather than away from, the bowl, which gives it something more the appearance of a saucepan than of a dipper.

The only other stars of any importance in the constellation are the two outer stars of the bowl of the Dipper. The brightest one is a second magnitude star, Beta Ursæ Minoris, sometimes called Kochab. The other is Gamma Ursæ Minoris, a third magnitude star. They correspond in position to the pointers in the Great Dipper, and are sometimes called the "guardians of the pole."

XXIII

THE GREAT BEAR AND THE SEVEN STARS OF THE DIPPER

UNLIKE the Little Bear, the Great Bear can be traced in the heavens with reasonable accuracy. It looks rather more like a chubby hobby-horse than a bear, and its long tail seems somewhat out of place. Still one can distinctly follow the outlines of a clumsily shaped four-legged animal, which, perhaps, is as appropriately called a bear as anything else.

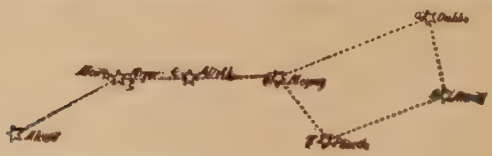
The most conspicuous part of the constellation is the Great Dipper. The handle of the Dipper is the tail of the Bear, and the four stars forming the bowl lie in the hind part of the body. The tip of the Bear's nose is marked by a star lying about twenty-five degrees from the root of the tail, and a line from the nose through the two stars forming the top of the bowl of the Dipper mark

the back of the Bear. Its right fore-foot is indicated by two stars about fifteen degrees south of its nose. The stars connecting this foot with the body show a prancing, double-jointed sort of a leg. Similar pairs of stars indicate the position of the other three feet, which can be appropriately connected with the body without much trouble, the whole forming an animal so huge that it might well give over its watch on Orion, since even so mighty a hunter would scarcely attack it.

Ursa Major is a remarkable constellation, not only because it is large and beautiful and always visible, but also because it contains so many things that are in their kind the most noted in the heavens. In it are situated the star with the fastest proper motion yet observed among all the northern stars (Groombridge 1830), and the one that of all the northern stars is nearest to us (Lalande 21,185). It contains also the first double star discovered with a telescope and the first binary system discovered by the spectroscope. Because of its rapid motion, Groombridge 1830 was long known as the "runaway star." Its speed is so great that it would show a displacement equal to about

one-third of the apparent diameter of the moon in a hundred years. A southern star has been discovered that moves still faster; but it is not visible in our latitude.

Ursa Major would be remarkable, however, if its only distinction was that of including the seven bright stars of the Dipper, which are well worth a closer acquaintance, on account of their many points of individual interest and beauty as well as their special interest as a group. With the exception of Orion, there is no other constellation with so many bright stars in so close a group. Alioth, the third star from the end of the handle, is the brightest of them, and barely escapes being a first magnitude star. All the others are of the second magnitude except



THE SEVEN STARS OF THE DIPPER

Megrez, which lies at the point where the handle joins the bowl of the Dipper. This is a third magnitude star.

After the first magnitude stars, there are

only two stars seen in our latitude that are brighter than Alioth. One of these is Castor, one of the twins, and the other is Adara, a bright star in the constellation Canis Major, or the Great Dog, the constellation of which Sirius is the brightest star. Alioth's magnitude is 1.68, and Castor's is 1.58, so that Alioth is only one-tenth of a magnitude less bright than Castor. It is five and a half degrees from Megrez, or Delta, the faintest star of the seven, and is four and a half degrees from Zeta, or Mizar. The name Alioth means the "tail sheep."

Alcaid, the star at the end of the handle of the Dipper, is the second in order of brightness in the group, though no longer ago than 1847 it was said by Herschel to be the brightest. It is thought by some astronomers to have diminished in brightness within the last century. The difference in brilliancy between Alcaid and Alioth is hardly discernible by the ordinary eye. The two are rated in the Harvard catalogue as of magnitudes 1.68 and 1.91, making Alioth the brighter by a little more than two-tenths of a magnitude. Alcaid is a Sirian star and is so far distant that its parallax has never been measured with any certainty. It is

approaching us at the rate of about sixteen miles a second. Its name means "the chief." The star is perhaps more frequently called Benetnasch. It is seven degrees from Mizar, the star next to it in the handle of the Dipper, and twenty-six from Dubhe.

Dubhe, or Alpha Ursæ Majoris, is the pointer nearest the pole. The name means the "she-bear." Dubhe lies in the back of the Great Bear, ten degrees from the star that begins the tail of the Bear. It is the third in order of brightness in the constellation, and is rated by Prof. Pickering as only four one-hundredths of a magnitude less bright than Alcaid. It is the only one of the stars of the Dipper that is solar in its type, and hence in about the same stage of development as Capella and the sun. Like others of its class, it is yellow in color and comparatively steady in its shining. While it is of the same class as Capella, it is probably rather more advanced, for it seems to change somewhat in color about once in fifty-four and a half days and become a little redder than ordinary. There is some difference of opinion as to these changes, and it may be that the period of change is not so regular as has been supposed. It is certain, however, that the

star seems redder at some times than at others even to the naked eye.

Dubhe is a binary, or spectroscopic double star. Its smaller companion is about nine magnitudes fainter than the larger star, being of the eleventh magnitude. This makes a vast difference in the brilliancy of the two stars, the brighter one being thirty-eight hundred times brighter than the other. Dubhe is a little more than twenty-eight degrees from Polaris; ten degrees from Megrez, the other star at the top of the bowl of the Dipper; twenty-six degrees from Alcaid, the star at the end of the handle, and a trifle over five degrees from the other pointer. It is approaching us at the rate of twelve miles a second.

The other pointer is Merak, or Beta Ursæ Majoris. It is fifth in point of brightness in the constellation, and is a very beautiful white star with a greenish tinge. It is a Sirian star as to its development, and thus is one of the youthful company of fair stars like Vega and Deneb. It is approaching us at the rate of about eighteen miles a second.

Merak is eight degrees from the other star at the bottom of the bowl of the Dipper, which is Phecda, or Gamma Ursæ Majoris.

This is also a Sirian star, but, unlike most of its class, it is tinged with yellow. It is sixth in order of brilliancy, its magnitude being 2.54. It is approaching the earth at the rate of 16.6 miles a second.

From Phecda it is four and a half degrees to Megrez, or Delta Ursæ Majoris, the faintest star of the seven bright ones in the Dipper. Its magnitude is 3.44. It is thought that Megrez, too, may be variable in brilliancy and that it has lost some of its brightness within the last century; but this is not certain. It also is of the Sirian type; but, like Phecda, it is slightly tinged with yellow. Its name means "the root of the tail," which describes its situation in the Great Bear. It is the star that joins the handle to the bowl in the Dipper. It is five and a half degrees from Alioth, the brightest of the seven, and is thirty-two and a quarter degrees from the pole.

The most variously interesting of all the stars of the Great Dipper is Mizar, or Zeta Ursæ Majoris, the star next to the one at the end of the handle. It is fourth in order of brightness among the seven, its magnitude being 2.09, almost an exact second magnitude star. It is one of the stars that are in

an early stage of development—that is, the Sirian class. Its parallax has never been found; but it is certainly one of the very far distant stars, and its light does not come to us in less than a hundred years, and probably requires a much longer time than that.

Mizar can always be known by its having a tiny companion so near it as to be sometimes not easy to see. Its name, Alcor, means "the near one." It was formerly known as "the test," because it was supposed to test the eyesight to see it. It is really not so difficult to see, however, for it is only a fourth magnitude star and is separated from Mizar a distance equal to almost one-third of the apparent diameter of the moon. The greater light of Mizar is what makes it seem so obscure. When Alcor is once known, it never fails to attract, for it is a peculiarly beautiful little star, very white and very piercing in its brightness. It is thought probable that Mizar and Alcor revolve about each other.

But Mizar has other stars nearer it than Alcor. It is the centre of a great system of stars. It has the distinction of being the first double star discovered by the telescope, a discovery made as long ago as 1650. When

the spectroscope came into use, Mizar was again the first to open up a new line of discovery, being the first star discovered by the spectroscope to be a binary. The larger of the two stars into which it was separated by the telescope was shown by the spectroscope to be also double. So the star as we see it is really three stars all united into one system. The pair of stars that require a spectroscope to separate them revolve around each other in a little more than twenty days and radiate nearly forty times as much light as the sun.

In England the Dipper is often called the Plough and sometimes Charles's Wain, or simply the Wagon. All of its stars except Dubhe and Alcaid have been found to be moving through space in the same direction and at about the same rate of speed, which indicates that they may all be of one system, or, at least, of a common origin, and thus be associated in reality as well as to our view. Dubhe and Alcaid are moving in an almost opposite direction from the other five stars, so that in the course of centuries the Dipper will be somewhat misshapen.

XXIV

CASSIOPEIA, CEPHEUS, AND THE DRAGON

CASSIOPEIA lies on the other side of the pole from Ursa Major and almost directly opposite the Dipper. Its chief naked-eye stars, seven in number, form a figure somewhat resembling a chair in shape. They are nearly as conspicuous among the circumpolar stars as the Dipper and are about the same distance from the pole.

On account of the faintness of the little star Kappa (κ), on the front edge of the seat of the chair, some persons leave it out of consideration and fancy the remaining stars outline a somewhat distorted "W."

Gamma (γ) Cassiopeiæ is at present the brightest star in the constellation, and is of the second magitude (2.25). Beta, also of the second magnitude (2.42), is the next brightest, and Alpha is but a shade less bright. Twenty years ago Alpha was rated the bright-

est, and on account of its change in brilliancy it is now thought to be a variable star. Delta (δ), the first star in the back of the chair, is also of the second magnitude (2.8).

CASSIOPEIA

Epsilon (ε), at the top of the back, is of the third magnitude (3.44); and Kappa, already referred to as the little star on the front edge of the seat, is a fourth magnitude (4.24) star. Eta (η), half-way between Alpha and Gamma, is an interesting binary, or double star. The two stars composing it complete a revolution around each other every two hundred years, and are comparatively near to us, being only about thirteen light years away.

Only two stars in Cassiopeia have individual names. Alpha is sometimes known as Schedar, and Beta was formerly called Caph. Polaris is just about half-way between Caph and Megrez, the star which joins the handle to the bowl of the Dipper, and is on the same side of the pole with Caph.

CEPHEUS

Next to Cassiopeia is Cepheus, the king, her husband. He stands with one foot on Polaris and his head reaching to Andromeda. The constellation has only one second magnitude star, Alpha, which was formerly called Alderamin, meaning "the arm." This star and Beta, a rather bright third magnitude star lying eight degrees nearer the pole than Alpha, point almost as directly to Polaris as the well-known pointers. They are a little nearer the pole than the pointers and are about three degrees farther apart.

When Cassiopeia is east of the pole, Cepheus is just above her. When she is above the pole, he is west of her; and when she is below it, he is just east of her.

THE DRAGON

The only other important constellation among those around the north pole is Draco, or the Dragon. It is supposed to represent, and does somewhat suggest, a great dragon which winds in and out among the circumpolar stars in graceful serpent-like convolutions. It is the Dragon on which the giant Hercules rests one foot. Its head is marked by a four-sided figure a short distance northwest of Vega, containing two bright and two faint stars. Since the head of Draco never sets, it is interesting to watch it when Vega is below the horizon, and one sometimes has a feeling that by a good big stretch on the tip of his toes he could see the bright Vega just below the shining eyes of the Dragon. The rest of the constellation is outlined by a number of faint stars. It runs a short distance towards Cygnus, and then with some well-marked undulations it runs up towards Cepheus until it is between Cepheus and the Little Dipper. There it turns, makes a sweep around the Little Dipper, and, running between it and Ursa Major, ends just above the bowl of the Great Dipper.

The two brightest stars in Draco are the

ones in the head. The brightest is the one nearest Vega, which is Gamma (γ) Draconis, sometimes called Etamin. The other is Beta (β), with the individual name of Alwaid. Gamma is a second magnitude star, and Beta is of the third magnitude. Gamma is a beautiful orange-colored star and is only about thirteen light years away from the earth.

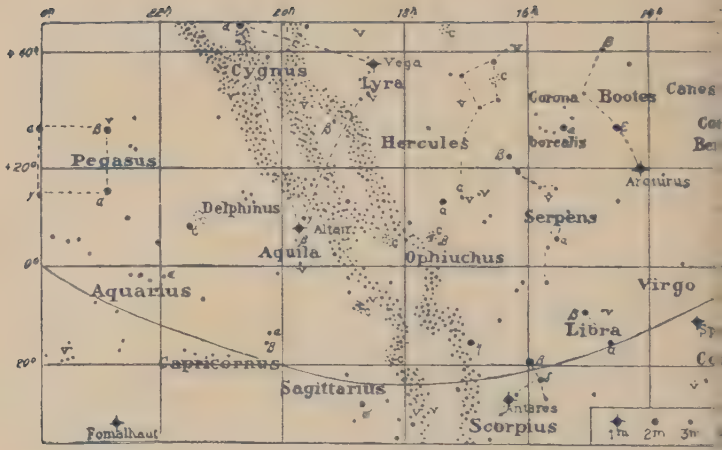
A small star near the tail of the Dragon, lying half-way between Mizar, of the Great Dipper, and the lower star in the bowl of the Little Dipper, is noted as having been the Pole Star four thousand years ago. Its name is Thuban, and it is the Alpha of the constellation, though Draco now contains seven other stars that are brighter.

XXV

FROM THE HUNTING-DOGS TO THE ARROW

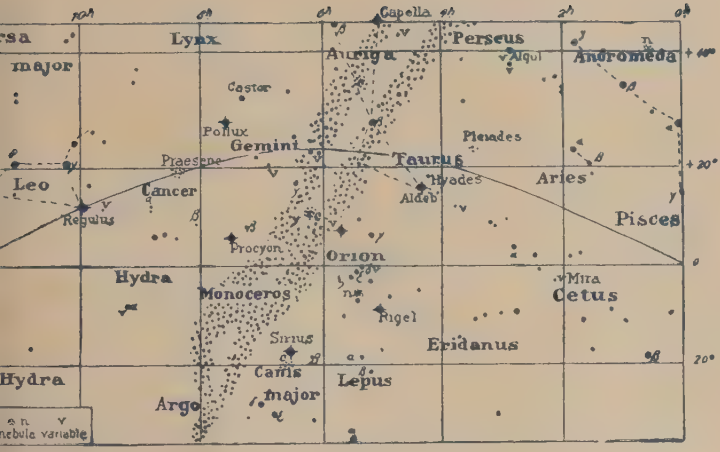
CANES VENATICI

JUST under the handle of the Great Dipper is a collection of faint stars called Canes Venatici, or the Hunting-Dogs. The only naked-eye star of any importance in it is Alpha, commonly called Cor Caroli. It gets its name from a modern attempt to make a constellation in honor of King Charles II. of England. The name means "the heart of Charles." When the handle of the Great Dipper is turned towards the west, Cor Caroli hangs under it in a very conspicuous position and is a star that one would naturally notice and inquire about. It forms a triangle with Arcturus and Benetnasch, or Alcaid, the star at the end of the handle of the Dipper. It is one of the brightest of the third magnitude stars.



THE MIDDLE

This includes all the important constellations visible in



OF THE SKY

e except those around the North Pole, shown on Plate I

It is also a double star, with a companion of about the fifth magnitude; but the two are too close together to be separated by the naked eye.

BOÖTES

Canes Venatici is a sort of connecting-link between the strict circumpolar constellations and those that make a somewhat larger circle around the pole and are not visible all the time. Perhaps the easiest way to find them is to look for them one by one as they follow each other up from the eastern horizon. Canes Venatici is supposed to represent two hunting-dogs on the trail of the Great Bear, and they are naturally followed by the hunter, or the bear-driver, Boötes, which rises next. The constellation is represented by a kite-shaped figure that rises about eight o'clock early in March. One can find it easily by the great star Arcturus, with which we are already familiar, and which lies in the knee of the hunter. It is a very pretty constellation and of some astronomical interest, but it is not remarkable to the ordinary view except for its one brilliant star.

CORONA BOREALIS

Corona Borealis, or the Northern Crown, is a semicircle of stars that rises just east of the northern part of Boötes. Its chief star Alphecca (Alpha Coronæ) comes into view just an hour and a quarter later than Arcturus. It is of the second magnitude, though much fainter than the brightest second magnitude stars. The constellation as a whole is a rather brilliant one, notwithstanding it has no star brighter than the fourth magnitude except Alphecca. There are seven principal ones, and most of them are of the white, twinkling kind, so that the crown is full-jewelled. The entire constellation is only about fifteen degrees across.

HERCULES

Next after Corona rises Hercules, one of the large constellations. It begins just south of the head of Draco and runs to within four degrees of the equator. The chief stars composing it make a figure something like the one shown in the diagram on the opposite page.

It is supposed to represent Hercules on one knee, with uplifted club and with one foot

on Draco's head. The figure is not very suggestive of the giant, but it is easily recognized by its geometrical outlines, and in some moods one may even fancy the resemblance.

HERCULES

Strangely enough, the position of Hercules is such that it is just as easy to trace the figure with its head to the north as to the south. The leg bent at the knee on one end and the uplifted arm on the other make somewhat similar outlines; and the body is not so shape-

ly as to lose much in either charm or definiteness of outline when it is regarded upside down. The head, however, properly belongs to the southern end of the constellation; for the main action of the figure consists in the hero's placing his foot on the Dragon's head, and Draco, we know, is north of him.

Hercules has no star as bright as the second magnitude, but has many of the third and fourth magnitudes, and has also several double stars. The constellation is directly north of Scorpius.

LYRA AND CYGNUS

Lyra, or the Harp, is the next constellation eastward from the northern part of Hercules. It contains the brilliant Vega, and its form has already been described. In addition to Vega, it has a famous star, Epsilon (ϵ); a variable star, Beta (β), which is also a double star; and a rare nebula, known as the Ring Nebula, on account of its shape. Epsilon can be divided into two stars by a sharp eye, and to try to see them is an interesting exercise. Each of the two is again double. Vega and Epsilon, with Zeta (ζ),

the star nearest to Vega in the parallelogram described on page 50, form an equilateral triangle each side of which is two degrees in length. This will enable one to find Epsilon.

Cygnus is the constellation that holds Deneb. In its rising it follows Lyra, and it has been fully described in the chapter on Deneb.

AQUILA, THE DOLPHIN, AND SAGITTA

In Aquila we recognize the bright Altair, which, with its two companions, already known to us, serves to indicate the constellation. Exactly eight degrees below Altair when it is on the meridian is a conspicuously variable star (Eta Aquilæ), which changes from the third to the fifth magnitude every seven days. Its changes are well-marked to the unassisted eye and make it an interesting object to follow from night to night. It is best seen in the early autumn, when Aquila is on the meridian during the first part of the evening. The two companions of Altair are Beta and Gamma Aquilæ. Beta is south of Altair, and Gamma is north of it. The line joining the three stars is just five degrees in length.

Aquila is supposed to represent an eagle flying towards the east and across the Milky Way.

The Dolphin, or Job's Coffin, in the shape of a diamond, is just east of Aquila and a little farther north than Altair. Three of the stars composing the diamond are a little variable; one of them is a double star, and another is a spectroscopic binary, which is also suspected of being a triple star.

Sagitta, or the Arrow, lies in the Milky Way, north of Aquila and south of Cygnus. It is composed of five stars so arranged as to suggest an arrow pointing towards the east. Though a very small constellation, it is pretty and easily found.

XXVI

FROM THE WINGED HORSE TO THE BULL

THE next constellation of any importance that we may expect to see in the east is Pegasus. It is nearly three hours after Altair is in view before the principal stars of Pegasus are seen coming up over the horizon a little north of east. It is a large constellation composed in the main of small stars. The chief figure in it is a large square called "the square of Pegasus." Each side is nearly eighteen degrees long, and the four stars composing it are sufficiently bright to make the square a significant figure in the sky.

On the southwestern corner of the square is a small triangle which serves as an identifying mark. The star on this corner of the square is called Scheat. It is Beta Pegasi and the third star in order of brightness in the constellation. Alpha Pegasi (sometimes

called Markab) is on the corner below Beta and is a very little the brighter. The other lower corner is marked by Algenib, or Gamma Pegasi, a star somewhat less bright than Beta; and the star in the fourth corner of the square, which is the brightest of them all, really belongs to Andromeda. Its individual name is Alpheratz. It was formerly Alpha Andromedæ and also Delta Pegasi; but it is not now included in Pegasus, although it is necessary to complete the square. The brightest star belonging to the Pegasus family is Enif, or Epsilon Pegasi. It marks the nose of the horse, and lies about ten degrees east of the little diamond of the Dolphin.

Pegasus is supposed to represent the winged horse, the favorite of the Muses. He rises up-side down, with his fore-feet pawing in the air up towards Cygnus and the top of his head resting on the urn of Aquarius. His position is such that he does not entirely right himself in his journey across the skies, as some of the figures of the constellations do; but ever on his back, he goes pawing across the heavens and down "into the depths of the ocean"—symbolic, perhaps, of the condition ascribed to those who ride him.

The hind parts of Pegasus are hidden by the rocks on which Andromeda lies, and her head is marked by the northernmost star of the square that outlines his body.

ANDROMEDA

The constellation Andromeda is supposed to represent a beautiful lady chained to the rocks. She was the daughter of Queen Cassiopeia and King Cepheus, who are near her in the skies and have been described, and she was brought to this situation because her mother boasted too much of her beauty.

The constellation is more than thirty degrees in length and is outlined by a row of four bright stars, beginning with the one in the corner of the square of Pegasus and running northeast across the heavens in a slightly curved and easily traced line under Cassiopeia. Andromeda and the square of Pegasus are shown in the illustration, together with the "segment of Perseus," which lies next to Andromeda.

The main stars in the two constellations are thought to somewhat suggest an immense dipper; but for that matter one can find a whole tinshop of dippers in the sky

if his mind runs that way and he is willing to admit a variety of styles in this useful utensil.

Andromeda rises cradled on the rock to which she is bound, her head lifted gently

ANDROMEDA, THE SQUARE OF PEGASUS, AND THE SEGMENT OF PERSEUS

into view by the great square body of Pegasus, on which it rests, and her feet, very properly, coming up last. But she sets in a most undignified fashion, drawn down by the flying Pegasus head first, leaving her feet waving above the horizon after the rest of her is out of sight. The four chief stars forming the curved line are Alpheratz, or Alpha Andromedæ, which marks the head; Delta, lying in the shoulder, from which an arm is outstretched towards the north; Beta,

or Mirach, marking the girdle; and Gamma, or Almach, indicating the foot. They are all second magnitude stars except Delta, which is of the third magnitude. Almach is a noted triple star which can be separated by the telescope. The components are orange, emerald, and blue.

A short distance north of Beta is the famous Andromeda Nebula, which is the brightest nebula in the entire sky. It can be plainly seen with the naked eye and looks like a hazy star. It is an enormous body of nebulous matter, estimated to be in length as much as thirty thousand times the distance of the earth from the sun, which we know is about ninety-three million miles.

PERSEUS

The hero that rescued Andromeda from her woful plight was Perseus, and he also is enshrined in a constellation, which adorns the sky in the region a little north of Andromeda. It lies in a very brilliant part of the Milky Way and is a beautiful constellation. The principal figure in it is a curved line of stars running from Cassiopeia towards Capella and called the "segment of Perseus."

About the centre of the segment is Mirfak, or Alpha Persei, a very bright second magnitude star, the brightest in the constellation.

The most noted star in Perseus is Beta, or Algol. It lies a little southeast of Mirfak and forms a triangle with it and Almach, the star in the foot of Andromeda. Algol varies in brightness from second to third magnitude once in about every three days (2 days, 20 hours, 48 minutes, and 55 seconds). It has been much written about as "the demon star" and "the slow-winking star." Since it varies at such short intervals and so markedly, it has long been an object of interest even to the naked-eye observer. The mystery of its changes has been made clear by the spectroscope, and it is now known to be a spectroscopic binary with a dark companion that eclipses it about once in three days. Its eclipse lasts about eighteen minutes, and for that length of time it is a faint third magnitude star. Then it regains its brightness and remains a second magnitude star until the next eclipse.

Algol is interesting to observers in the latitude of New York City as being the only star as bright as the second magnitude that comes very near our zenith, or the point

directly over our heads, on its course across the heavens. When on the meridian it is only about one-tenth of a degree from our zenith. Algol rises about an hour earlier than Capella. Perseus has two very beautiful star clusters which make a splendid display with the aid of ordinary opera-glasses.

AURIGA

Auriga rises next after Perseus in the northeast. It is the constellation that contains the charming Capella, which is, of course, its brightest and most important star. Its five brightest stars outline a five-sided figure which somewhat resembles a shield. Aside from Capella, the constellation has only one star as bright as the second magnitude. This is Beta Aurigæ, or Menkalinan. The other three stars of the pentagon are of the third magnitude. Auriga is supposed to represent a goatherd holding a small she-goat in his arms.

TRIANGULUM

Just below, or east, of Andromeda is a pretty little constellation called Triangulum,

or the Triangle. There are only five stars in it, and the brightest one is only of the third magnitude. Two others are of the fourth, and two of the fifth magnitude. It rises about half an hour after Andromeda.

ARIES

Next east of Triangulum is Aries, a small but important constellation. Its importance consists in its being one of the constellations of the Zodiac, which mark the path of the sun. The sun passes through it from April 15th to May 13th; so that six months later it is exactly opposite the sun in the skies and rises just as the sun sets. It is the first sign of the Zodiac; but owing to the precession of the equinoxes the signs of the Zodiac do not now correspond with the constellations of the same name. From the middle of March to the middle of April, when the sun is in the sign of Aries, it is in the constellation Pisces; and when it is really in the constellation Aries, it is said to be in the sign Taurus.

The chief stars of Aries form a triangle in size about like Triangulum, and the two constellations are sometimes mistaken for each

other by observers not entirely familiar with these constellations. It should be remembered that Triangulum rises first and is about half-way between Aries and Andromeda, and that the apexes of the two triangles point in different directions.

The chief star of Aries is Hamel. It rises about three-quarters of an hour after Algol and about fifteen minutes before Capella. It is the brightest star in the constellation and is of the second magnitude. The next brightest is Beta Arietis, or Sheratan. It is about one-half a magnitude less bright than Hamel and is about three degrees below, or east of, it in the sky. The two stars mark the base of the two horns of Aries, or the Ram.

TAURUS

Taurus is the splendid constellation in which Aldebaran lies, and can always be recognized by that bright star. It is the third constellation and second sign of the Zodiac. The sun passes through it from May 13th to June 18th; so it may be seen rising as the sun sets six months later—from the middle of November to the middle of December.

Taurus contains the cluster of the Hyades,

which are supposed to rule over wet weather and are sometimes referred to in poetry as the "moist Hyades." Aldebaran, as we have seen, is one of this cluster. The cluster outlines the face of the Bull. Above it are the Pleiades, which lie in the Bull's shoulder. The tips of the horns are indicated by two stars up near Auriga, one of them, indeed, lying inside the boundary of that constellation.

The Bull rises backward, with its head lowered under the threatening arm of Orion, and it backs all the way across the heavens, going down without having made the terrible onset which it all the time promises.

XXVII

THE MYSTERY OF THE PLEIADES

OF all the groups of stars in the heavens there is none that has excited so universal and so romantic an interest as the Pleiades. The magic of their quivering, misty light has always made a strong appeal to men of imagination. Minstrels and poets of the early days sang of their bewitchment and beauty, and many of the great poets, from Homer and the author of Job down to Tennyson and the men of our own day, have had their fancy enlivened by them, and in one form or another have celebrated their sweetness and mystery and charm. By men of fancy they have been compared to a swarm of fire-flies, to bees, to a rosette of diamonds, and to shining dew-drops, and by less ecstatic minds to a hen and chickens and the seven virgins. Even with people who do not know them by sight and have not felt "the sweet

influences of Pleiades," there is a vague memory of some story about a lost Pleiad that stirs an emotion suggesting something romantic and sad.

The Pleiades form, in truth, a delightful group of twinkling, unfathomable stars, singularly fascinating and singularly persistent in their brilliancy. Of the six that can usually be seen with the naked eye, all but one are of the fourth magnitude and are not much brighter than the tiny Alcor, Mizar's companion. Yet often when the moon is full and many of even the third magnitude stars are practically extinguished by its greater brilliancy, the Pleiades hang in the sky like a small luminous cloud distinctly visible and commanding admiration. When the moon is dark, they are hardly less conspicuous than a first magnitude star, and one sometimes fancies what a splendid great star they would seem to us if they would only huddle a little closer together so that we could see them as one.

Still, even on the surface of the sky just as we see them, they are not so close together as we often regard them. The full moon, which to casual observation seems to cover a so much greater area than they, can move

about among them, most of the time covering only one visible star at a time. This occurs when the Pleiades are occulted by the moon, a phenomenon which is sometimes seen, since the Pleiades lie within four degrees of the centre of the Zodiac, in which, as we know, lies the path of the moon. The whole constellation covers a space of a little more than three square degrees, while the apparent diameter of the moon is but little more than half a degree. It is hard to believe that it

THE PLEIADES

would require four or five moons together to cover the little dipper of the Pleiades from our view entirely, but it is true. The moon looks so much larger because of its brilliancy. Its size as compared with other objects in the heavens is very deceptive.

The principal stars of the Pleiades form an outline resembling a short-handled dipper.

I have more than once been asked if this was the Little Dipper. It is, of course, in an entirely different part of the sky from the constellation called the Little Dipper, the one which has Polaris at the end of its handle. The Pleiades are in the constellation Taurus. They rise just an hour earlier than Aldebaran and are visible at the same seasons as that bright star. We see their shining light during the first cold evenings of autumn. On Hallowe'en they are about half-way up from the horizon between nine and ten o'clock. In the winter, they are high in the sky during the early evening, tending more and more towards the west as the season advances. In March they set between nine and ten o'clock, and in April they disappear from the evening skies.

Any one can see the six principal stars of the Pleiades; many can see seven, and sharp eyes can distinguish anywhere from eight to eleven. There are so many stars in the group that are just beyond the limit of easy visibility that to any eye the number varies according to the clearness of the atmosphere and other physical causes. Even from mo-

ment to moment they twinkle in and out of our vision. It was no doubt this characteristic that suggested the simile of a "swarm of fire-flies." There are, in fact, more than three thousand stars in this small group. They cannot all be seen with a telescope, but they have recorded the fact of their existence on the photographic plates.

By means of photography, too, we have learned that they are all enwrapped in a vast body of nebulous matter—"a cosmical fog," it has been called—which hangs around them like a great veil, gathering itself into wisps here and there and in some instances making something like festoons from one star to another. Slight traces of this great cloud of nebula were seen more than fifty years ago through the telescope, but it is only within the last few years that the extent and significance of it have been learned.

Taken in connection with the fact that most of the stars in this vast nebula show spectra very much alike and are nearly all of the Sirian type, indicating an early stage of evolution, astronomers find evidence that the principal stars of the Pleiades are closely related in their origin and development. The chief stars of the group have the same

general motion in the heavens, and more than forty of the fainter ones have been observed and are found to be moving along with the system.

There is scarcely a doubt that it is a great system gradually developing from the tremendous mass of nebula in which it is engulfed. For millions of years it has been condensing into great stars like Alcyone and others as large or larger. In comparison with them our sun is small indeed, and at the same distance could be seen only with a good telescope. Perhaps even the greatest telescope would be required, for all attempts to find the distance of the Pleiades from us have yielded no certain results. The most we can learn is that they must be at least two or three hundred light years away, and may be much farther than that. According to Ball, the group "must be millions of times as remote from the earth as the sun, and many of the stars of the Pleiades must be hundreds of times more lustrous than the sun." Alcyone, for example, is supposed to be about sixty times more brilliant than Sirius, and other stars of the Pleiades are not less bright.

In keeping with the magnificent scale on

which the whole system is constructed is the distance of the individual stars in it from each other. Most of them, it is supposed, must be almost as far apart as the distance of the nearest fixed star from us. Light comes to us from the sun in eight minutes, but to travel from one Pleiad to another it would require not less than three or four years, and perhaps even longer. Many such solar systems as ours could be placed between any two of the principal stars of the Pleiades and still have room enough. Yet so distant are they from us that with this vast space between the individuals the group shows to us only the tiny cluster of twinkling stars, small enough to barely cover the jewels in Orion's belt.

We may know more about the Pleiades as time goes on, but they will never be any nearer to us or any brighter to our view. They may indeed in future ages be even less bright, for every second of our lives the distance between us and them is increased by many miles. Our sun, with us, his children, is travelling through space away from the Pleiades at the rate of about thirteen miles a second, while they are headed towards another part of the universe and travelling

at no less a rate. And yet, in seeming contradiction to this, under the old Hindu conception of the material universe, Alcyone, the brightest star in this group, is supposed to be the centre around which our sun with all its planets and other suns with their planets are revolving in immense orbits, covering quadrillions of miles and requiring billions of years for one circuit. This idea has been somewhat revived recently, not so much by astronomers or scientists as by speculative philosophers who are expounding the metaphysical thought of the East. One or two modern astronomers have at least not rejected it, so far as our sun is concerned, and one has even ventured to say that the star is probably about seven hundred and fifteen light years away from us and that our sun revolves around it in a period of about twenty-two million years. But astronomers generally do not find sufficient foundation for this belief.

The nine brightest stars of the Pleiades bear the names of Atlas and his seven daughters and their mother, the nymph Pleione. Atlas is the star at the end of the handle of the dipper formed by the stars. Pleione, the mother, lies just above him, and is generally

supposed to be the lost Pleiad, since it is difficult for some persons to see her. Alcyone, the brightest of them all, is of the third magnitude, and lies at the joining of the bowl and the handle of the dipper. Electra, the second star in point of brightness, lies in the bottom of the dipper and is of the fourth magnitude. It is but a shade brighter than Atlas, and the ordinary eye can see no difference between the two. Maia, which lies about the middle of the top rim of the bowl; Merope, in the back corner of the bowl, and Taygeta, at the front edge of the brim, are all fourth magnitude stars. Celæno, a little fainter, is about half-way between Electra and Taygeta; and Asterope, the faintest of her family, lies a short distance above Taygeta. Asterope is between the seventh and the eighth magnitude, and very few persons can see it without the aid of a glass.

Asterope, Taygeta, and Atlas each have a companion star — that is, they are double stars. The two stars comprising Asterope are each of about the seventh magnitude; the two composing Atlas are one of the fourth and one of the fifth magnitude. Of Taygeta's two stars, one is nearly one hun-

dred times brighter than the other. They are of the fifth and the tenth magnitude.

From the persistence of the story of the "lost" Pleiad and the almost universal reference to them as "the seven stars," it is thought that one of the fainter ones may formerly have been brighter, but it is not certain which one. Electra is sometimes mentioned as having veiled her face on account of the destruction of Ilium, and sometimes as having been carried off by Canopus. If she is the lost one, it is in no physical sense, for she still shines the second in brightness of them all. The like is true of Merope, who has been said to be the lost one because she married the mortal Sisyphus, but she is still among the six brightest Pleiades. Celæno has been reported to have been struck by lightning and thus lost, and there is no evidence refuting this, for Celæno is almost a seventh magnitude star and is difficult to be seen with the naked eye. Pleione, however, which is also nearly a seventh magnitude star, is the one generally supposed to have lost something of its brilliancy in the course of years, which, in the absence of any astronomical reason to the contrary, is a humanly probable supposition,

since she was the mother of them all. It has also been suggested that the lost star may have been a *nova*, or a new star, which has faded away, as others of its kind have done.

XXVIII

FROM THE TWINS BACK TO THE HUNTER

GEMINI is the constellation of the Twins, already described. It rises about the same time as Taurus and is next north of it. Gemini is the fourth constellation and third sign of the Zodiac. The sun passes through it from June 18th to July 18th. Hence it can best be seen from October to May.

CANIS MINOR

Canis Minor lies south of Gemini and is already known to us. It is the constellation containing Procyon; and though it has seven other stars, none of them is of any particular interest. It represents a very small dog on the back of a horse. The horse is a constellation in itself, and is called Monoceros; but it is insignificant and contains no star brighter than the fourth magnitude.

CANCER

This is a small constellation containing no star brighter than the fourth magnitude, and out of its fifteen naked-eye stars only four are as bright as that. It is the fourth sign and the fifth constellation of the Zodiac. After leaving Gemini, the sun passes through Cancer from July 18th to August 7th. The constellation includes most of the stars in the region between Pollux and Regulus. Its most interesting feature is Præsepe, a beautiful star cluster shaped somewhat like a beehive and lying about ten degrees south of Pollux. It is visible to the unaided eye.

LEO

Leo, or the Lion, is the constellation containing the first magnitude star Regulus, with which we are familiar. It is the fifth sign and the sixth constellation of the Zodiac, and the sun is travelling through it from August 7th to September 14th. It is best seen from January to June. It is supposed to represent a couchant lion and is one of the rather conspicuously displayed constellations.

It contains three stars of the second magnitude, Beta, Gamma, and Delta Leonis. Gamma is the brightest star in the blade of the Sickle. Beta, more frequently called De-

LEO OR THE LION

nebola; Delta, sometimes called Zosma, and Theta form a conspicuous triangle. Zosma lies in the back of the lion, at the beginning of the tail, and Denebola marks the tuft at the end of the tail. The triangle is visible in the northwest in the early summer for nearly two hours after the Sickle has set.

COMA BERENICES

Just east of Leo is a small cluster of stars called Berenice's Hair. It is interesting mainly because of its delicate beauty.

This brings us back to Boötes in our circuit of the constellations south of those sur-

rounding the pole and north of the equator. The next round will include the constellations coming within our view that lie either in part or wholly south of the equator.

XXIX

CONSTELLATIONS WHOLLY OR IN PART SOUTH OF THE EQUATOR

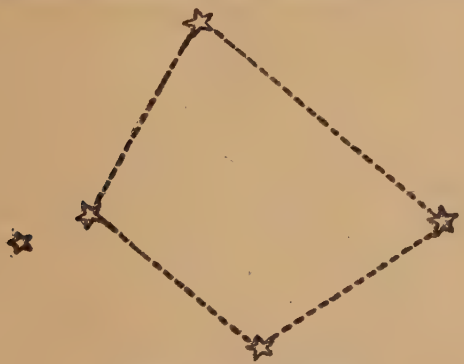
VIRGO

SOUTH of Coma Berenices and Boötes is Virgo, the sixth sign and the seventh constellation of the Zodiac. It lies about half north and half south of the equator and is one of the largest of the constellations, but not one of the richest in stars. There are only about thirty-eight or forty naked-eye stars within its boundaries. One of these is Spica, already known to us. The next brightest is Gamma, a remarkable binary lying about ten degrees north of Spica. It has a period of one hundred and eighty-five years. Its magnitude is 2.91. All the others are of the third magnitude or less. The sun occupies Virgo for forty-three days, passing through it from September 14th to October 29th. Its stars being comparatively faint and much scattered, it is difficult to trace. It is sup-

posed to represent a goddess with wings, bearing a sheaf of wheat in one hand. Spica, as we have seen, is in the ear of wheat. The outline of the maiden is so entirely fanciful that it is impossible to follow it; and for the ordinary observer it is sufficient to know that the constellation occupies all the space from Leo to Libra on the west and east, and from Boötes on the north to Hydra on the south. Denebola, Spica, Arcturus and Cor Caroli form a large diamond, almost fifty degrees in length, called "the diamond of Virgo."

LIBRA

Libra, or the Scales, is a small constellation lying wholly south of the equator, into which



LIBRA OR THE SCALES

the sun passes when it leaves Virgo on October 29th. It occupies this constellation until November 21st. Libra has no star brighter than the third magnitude. Its chief stars form a four-sided figure that is easily identified.

It is seen during the summer months crossing from southeast to southwest, where it disappears in November.

SCORPIUS

Scorpius is known to us through its brightest star, Antares. It has in addition four stars of the second, seven of the third, and nine of the fourth magnitude. It is the ninth constellation and the eighth sign of the Zodiac, and is occupied by the sun from November 21st to December 16th. It is the most southerly of the constellations marking the path of the sun, and is farther south than any other constellation of which we have a complete view. But inasmuch as the sun does not pass through the most southerly part of Scorpius, it is not the constellation that contains the point farthest south in the Zodiac. We can see it from about June 1st until late in October.

SAGITTARIUS

Sagittarius is the ninth sign and tenth constellation of the Zodiac. In it lies the most southern point of the Zodiac. The sun enters it on December 16th and reaches the most southerly point of its path five days later, December 21st. It is east of Scorpius and lies in the Milky Way. It can be easily recognized by a little figure like a dipper turned upside down, which is called the "Milk Dipper" because it lies in the Milky

THE MILK DIPPER

Way. It is very conspicuous during August and September.

Sagittarius represents a centaur in the act of shooting an arrow. The curved line of

stars represents the bow; the one extending into the Milky Way and the one farthest east in the Dipper represent the arrow and the bent arm pulling the cord. Sagittarius has two stars of the second magnitude, nine of the third, nine of the fourth, and twenty-eight of the fifth magnitude. The Milk Dipper is almost seventy degrees directly south of Vega and is almost as far south of the equator as Vega is north of it.

OPHIUCHUS AND SERPENS

Ophiuchus and Serpens also lie on both sides of the equator. They form a sort of combination constellation that occupies the space between Hercules on the north and Scorpius on the south and branches out into both of them rather too much to be easily defined, particularly as it contains no very bright stars. It is supposed to represent a man bearing a serpent. The two legs of Ophiuchus run down into Scorpius, and the head bumps into the head of Hercules, which is on the southern end of that constellation. The serpent is more easily traced. Its head is just south of the Northern Crown, and thence it winds down alongside the head of

Hercules, across Ophiuchus, and up on the eastern side of him to Aquila. It is a distinct and pretty line of small stars, fairly close together and sometimes almost in pairs, winding around through this region of the skies; and it is particularly well defined in August and September, when it is rather low in the southern heavens.

CAPRICORNUS

Capricornus, or the Goat, is the tenth sign and eleventh constellation of the Zodiac, and lies southeast of Aquila. The sun occupies it from January 18th to February 14th. It has no conspicuous stars, and no figure definitely outlined that can be described; and yet on a clear night the comparatively faint stars dancing about in it are sometimes suggestive of a capering goat, if one does not try to be too definite. Alpha and Beta, which are in the head of the Goat, are about twenty degrees south of Altair and point towards it. They are about two and one-half degrees apart, and are attractive out of all proportion to their brilliancy. Near Alpha is a faint fifth magnitude star that is even a better test of vision than Alcor.

Capricornus lies east of Sagittarius and south of the Dolphin.

AQUARIUS

Aquarius covers that part of the Zodiac which the sun occupies from February 14th to March 14th. The best time to observe the constellation is when it is farthest away from the sun, in August, September, October, and November. It has three stars of the third magnitude and none brighter. It is of a peculiar and straggling shape, extending around Capricornus on the north and east. The eastern part of it is south of Pegasus, and the western part is south of Delphinus. It is supposed to represent a man pouring water from an urn. Its distinctive feature to the naked eye is a waving line of faint twinkling stars that somewhat suggest a stream of water, and which lead down to our old acquaintance Fomalhaut, in the mouth of the Southern Fish (*Piscis Australis*). Aquarius is the eleventh sign and the twelfth constellation of the Zodiac.

PISCIS AUSTRALIS

Of this constellation all we need to know

is that it consists of Fomalhaut and the few fifth magnitude stars surrounding it.

CETUS

Cetus is a large constellation lying almost entirely south of the equator. It represents a huge sea monster and is sometimes called the Whale. The head, marked by a small triangle of stars, is on the equator and lies directly below Aries, about twenty-two degrees south of the principal star (Hamel). The body stretches along below Pisces and down to Aquarius, over a distance of more than forty degrees. The body is outlined by a four-sided figure easily distinguishable in this rather sparsely-starred region, and the tail is marked by the only second magnitude star in the constellation—a rather pretty yellow star sometimes called Diphda. The most noted object in Cetus is the star Mira (The Wonderful), its Greek letter name being Omicron Ceti. It is a remarkable variable star and changes in light all the way from the second to the ninth magnitude. It is visible about two months out of every year, and reaches a certain maximum of brightness about every eleven months. But astrono-

mers have not yet been able to predict how bright it will be at these maxima. Sometimes it is not much more than visible and sometimes it is of the second magnitude. Once, in 1779, it is reported to have been as bright as Aldebaran. It has been under observation for three hundred years.

ORION

Orion is the most brilliant of all the southern constellations. It has been fully described in the chapter on "Orion's Bright Stars." It rises just after Taurus and is visible from late October to May.

LEPUS

Lepus, or the Hare, is a small constellation just south of Orion. It is very pretty in the winter, but too low down in the sky to be seen clearly except when Orion is well up in the heavens.

ERIDANUS

Eridanus is a stream of stars beginning just west of the Orion Nebula and meandering west and south among the stars until it

is lost below the southern horizon. Achernar is its only first magnitude star, and this is too far south for us to see it. Though most of the stars are faint, the constellation is easily traced because so few stars are near it.

CANIS MAJOR

Canis Major, or the Great Dog, lies just east of Lepus and south of Monoceros. It can always be known by its bright star, Sirius. It represents a dog standing on his hind feet and pawing in the air in front of Lepus, the Hare. Sirius marks the nose of the dog; Adara, a star nearly as bright as the first magnitude, is in the flank; and Mirzam, or Beta, scarcely less bright, is in one forepaw. There are two other second magnitude stars, making the constellation, as a whole, one of considerable brilliancy, even without the great Sirius. It contains forty-one stars that can be seen without a glass.

HYDRA

Hydra, the Water Snake, is a straggling constellation that covers between ninety and one hundred degrees in its length, and has

but one star of any considerable brightness. This is a second magnitude star, sometimes known as Cor Hydræ (the Heart of the Snake), sometimes as Alpha Hydræ, and sometimes as Alphard, the Solitary. It is a reddish star, about twenty degrees south and a little west of Regulus; and, as its name indicates, it has no other bright star very near it.

Cor Hydræ rises about half an hour later than Regulus, reaches the meridian three-quarters of an hour earlier, and sets two and one-half hours before Regulus disappears. The Water Snake itself has its head directly south of Præsepe in Cancer and about halfway between Procyon and Regulus. The body runs southeasterly (outlined by Alphard and numerous faint stars), below Leo and Virgo, and ends under Libra. Except for its one bright star, Hydra is of no particular interest.

The back of Hydra serves as a resting-place for two very pretty constellations known as Corvus, the Crow, and Crater, the Cup. Corvus is a little to the southeast of the star Spica, and has four principal stars forming a four-sided figure with a little star out at one side, making the outline somewhat resemble Libra. The four stars are rather bright

third magnitude ones, and the constellation is a conspicuous one during the spring and early summer months when Virgo and Leo are in prominent places in the sky.

PISCES

This constellation is the twelfth sign and first constellation of the Zodiac. It has no bright stars, and is best described as the body of stars occupying the space from Aquarius to Aries and running below Andromeda and Pegasus and north of Cetus. It is supposed to represent two fishes tied together with ribbons, a very inappropriate combination; and it is not impossible to imagine that the faint stars running through it do outline something of the sort, but certainly not with any definiteness. It is in no way to be confused with Piscis Australis, or the Southern Fish, which is an entirely different constellation. The most important thing about Pisces is that in it lies the point where the ecliptic, or path of the sun, crosses the equator. This point is passed by the sun on its way north in the spring and is called the vernal equinox. The line running from one pole to the other and passing

through the vernal equinox is the one from which astronomers measure the right ascension of the stars (equivalent to longitude on the earth). For this reason Pisces is an interesting constellation, and it is to be regretted that it has no bright star to mark so important a point.

XXX

INDIVIDUALITY OF THE STARS

WE ought now to begin to feel at home in the presence of the general company of stars. We have been introduced to most of the choicer and greater individuals among them and have had a general view of their brilliant assemblage as it appears from night to night and from season to season and a slight insight into their common life. If any permanent relation is to ensue we must now—each for himself—make our own friends among them. What most interests one may not most interest another. We do not feel alike in regard to people or other objects in nature, why should we in regard to the stars? The more of individuality any thing or person has, the surer are we to have a decided feeling of attraction or repulsion for it, a readiness to admit it to our regard or to let it pass with the unnumbered individuals that make no impression upon us.

More than any other natural objects, the stars, as they appear to us in the skies, seem to me to have individuality. Each lovely flower that we see is one of a species, and however much character we may find in the species, every individual is known only by its being a duplicate of thousands of others in petal, sepal, stamen, and anther. The shy hermit-thrush and the friendly robin in their perfect normal state must conform to their kind even to the color of their bills. But there is only one Vega, one Capella, one Arcturus, and they are no more duplicated in nature than they are in name.

What the general character of a star seems to us depends upon ourselves, the peculiarities to which we are sensitive and the play our fancy takes in the interpretation of them. But the traits which go to make up this general character have their basis in facts and are by no means products of a freakish imagination. Nearly every one has some sensitiveness to color and will receive an impression when he marks Antares as red, Vega as bluish, Castor as tinged with green, and the various other stars as having their own peculiar tints. This will have an additional meaning, perhaps, when he remembers

that these great white stars with tints of various colors are really in an early stage of existence in the life of a star, that they are indeed youthful, that their intense twinkling and dancing light is in keeping with their age. It will then be but natural to remember that Capella, Procyon, Pollux, and Arcturus and the other stars of a like yellow hue are the mature stars and very properly have a sedate manner of shining, with a somewhat steadier light and less scintillation; and that Antares, Betelgeuse, and Aldebaran are the Nestors among the stars, with still less motion in their rays and less animation in their general aspect, Betelgeuse even going so far as to let his eyelids droop at intervals and thus become a variable star, which is thought to be one of the marks of advanced age in star life.

Color carries with it also some impression of the actual substance of a star when one has learned that the fair stars of the Sirian type are probably light in mass in comparison with their brilliancy; that those more or less of the solar type, like Procyon, Polaris, and Capella, are of somewhat more substantial composition, tending away from the volatility of youth and probably sending out

more heat in proportion to their brilliancy than the lighter, more tenuous, and younger stars; and that the red stars, of which Antares is a type, are still more compact, still less brilliant, and in their natural evolution are growing all the time to have less of sparkle and more of solidity.

One must also get some impression of individuality as he learns something of the motion and distance and dimensions of a star. Our personal estimate of a star and relation to it cannot but be influenced by such facts as that Altair is comparatively near us, while Deneb and Spica, which can be seen at the same time, are unmeasured, and so far as we know unmeasurable, distances from us; that one star whirls over its orbit in seven hours and another spends hundreds of years accomplishing the same task; that one flies at the rate of two hundred miles in a second and another loiters along at a pace scores of times slower; that one is plunging towards us, another is receding from us, and that whatever its rate or direction, each is pursuing its own peculiar path.

The length of its stay with us, the time of year that we see it most, and the personal association we have with it must also have

some effect on our relation to a star. There must always be less of intimate pleasure in the presence of a star like Fomalhaut, for instance, which comes for only a few months each year and makes a short, swift passage along the southern edge of our skies, than with such stars as Capella and Vega, who turn their shining faces towards us throughout the entire night so many months in the year. There is likely to be more warmth of feeling for the bright Spica, who shines during all the rich soft nights of summer, than for the equally bright Rigel, who dances along almost exactly the same path during the cold, crisp winter nights. Certain stars that may have the intensest charm and companionability for us if we first learn to know them as they hang during the rich black nights under the great dome that arches over spacious fields and valleys, may scarcely attract a passing thought from us if we meet them first in the narrow alleyways of the city streets, or even in the hazy, half-lighted atmosphere that envelops the higher points in the city.

Even the name of a star imparts some flavor to one's general notion of it. Some names are essentially feminine, some dis-

tinctly masculine, some have a meaning that cannot be overlooked, and some appeal to one's fancy by mere association of sound.

As we come into closer acquaintance with the stars and give heed to them, such characterization comes about as naturally as it does with any other objects that play into our lives. In my journal of out-door things I find mention of perhaps thirty or more stars that seem to me to have well-defined traits which are indissolubly attached to my idea of the star. Antares, for example, seems old but important and impressive, Capella fair and mature, Vega young and fresh and joyous, Arcturus full of dignity, Sirius brilliant without much impressiveness, Betelgeuse gloomy even to the point of being foreboding, and suggestive of the sullen redness of the light before whose warning eye the swift electric trains come to a dead stop. Dubhe and Merak seem fair and smiling as they graciously point the way to the North Star, Mizar suggests friendliness, Alcor faithfulness, Aldebaran sturdiness, the Pleiades delicate charm, Fomalhaut serenity, Castor and Pollux gentleness and kindness and affection, Mira instability, and Polaris its opposite—stability and responsibility.

Many more might be added to this list, but I have no desire or expectation that others may have the same impressions that I have concerning individual stars. Circumstances may lead them to lay stress upon quite different traits which are as truly characteristic of the star as the ones which have appealed most to me. These have been mentioned to indicate the pleasant familiarity that one may come into with the individuals composing this great body of nature that is before our eyes every night of our lives, and to create this sort of an interest in them is the sole aim of this book.

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